The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

Vol. XVI. PITTSBURGH, PA., MAY, 1928 No. 5

The Steel Maker

By Frank F. Cramer

We are descendants of Vulcan, the Forger,
Grandsons of old Tubal Cain,
Sons of the men who made swords at Damascus,
Kins to the smelters of ancient Spain;
Tracing our lineage back thru the ages
When mythical gods made war on our sires,
Back where the gods dealing death and disaster
Cast down their bolts bringing iron in their fires.

We are the heirs of their knowledge and prowess
Handed from history's dawn;
Heirs to their methods, their skill and their practice
And heirs to their strength, with pride in our brawn;
Furnacemen, blowers, melters and pitmen,
Handling a shovel, a lever or peel,
Heaters and rollers, straighteners or loaders
All of us mighty men, real men of steel.

We are the makers of civilization
Progress is measured by steel;
Steel for the tools of farmers or surgeons,
Plowshares and lancets or automobiles;
Buildings and bridges, cannon or shrapnel,
Tubing or rails or a steamship's keel
We, the descendants of Vulcan, the Forger
Take pride in our calling and boast of our steel.

*Timken Roller Bearings for Steel Mills**

Information Is Presented from Tests Run on a 22" Bar Mill, a 10" Rod Mill, a 26" Tube Mill and Four-High Mills—Lubrication and Life of Bearings Considered

By F. WALDORF

IN order to roll steel, one must use rolls and a full complement of component parts that go to make up a rolling mill. He does not necessarily need to use roller bearings, for the steel can be rolled as well on plain bearings, although at the expense of power, and therefore when one attempts to extol the merits of only a small part of a mill, as, for instance, the roller bearings, he does not have so large a field to work in.

However, the success that has so far crowned the efforts of the steel mill industry to adopt anti-friction bearings in the process of rolling steel has been both gratifying and encouraging. The benefits derived when considered from the four viewpoints—power saving, maintenance, repairs, and output, have been extremely satisfactory.

Savings in power as measured in dollars and cents is, of course, the benefit that holds the greatest appeal to the producer and we believe that in time such savings will be reflected in lower prices to the consumer. Maintenance costs are at once reduced to such levels as to be considered mere incidentals, and repair bills are naturally reduced to the point of being almost negligible. Output, by virtue of being almost uninterrupted, except for shut downs for roll changes, shows a satisfactory increase over that enjoyed with plain bearings, and marked improvement in the quality of some products has been obtained through the smoother and more accurate operation of mills with roller bearings on the roll necks.

Loads Determined by Brinell Tests

The loads encountered while rolling steel, were determined with Brinell plates and hardened steel balls which were placed between the breaker block and the top roll rider, and the bearings were designed for these loads.

When a Brinell test is made, the loads imposed upon the roll necks by the steel in resisting deformation are transmitted to the screws by the balls between the plates. Each ball leaves a definite impression in the softer of the two plates, and these impressions are later duplicated in a testing machine. The pressure required to reproduce each impression is recorded and the total load on each neck is taken to be equivalent to the sum of the pressures required to make the individual duplications in a plate.

Our initial rolling tests were made on the middle roll of the break down stand of our 22-in. 3-high bar mill. Owing to the housing limitations we could not get bearings on any of the rolls, but the middle one, and on that, only by reducing the neck diameter from 14 in. to 13½ in.

A four row bearing was built. This had a capacity of 400,000 lbs. at 60 r.p.m. and dimensions of 13½ in. x 21 in. x 11½ in. After rolling considerable tonnage of 8 x 9 blooms to 4 x 4 billets without having any trouble with this bearing we decided that such a large capacity was not required. We therefore removed half of the rollers of each bearing from the necks, thereby reducing its capacity to 200,000 lbs., but the same rolling duty had no effect upon it.

In order to impose extreme loads on this two-row bearing we decided to roll cooled blooms and in order to determine what loads actually occurred while rolling them we inserted Brinell plates as before described. Neck loads as high as 658,000 lbs. and 416,000 lbs. were imposed but the bearings suffered no injury. We then decided to weaken the two row bearing by removing every third roller and we rolled 6500 tons on the bearings in that condition before failure occurred. An inspection showed how thoroughly unbalanced the bearing was and you will admit that it stood up very well to last as long as it did.

We then replaced the halves of the bearings that had been taken from the original four rows and rolled steel until the completion of the test. In all, over 40,000 gross tons were rolled during this experiment. With the experience on the 22-in. mill to guide us we next turned attention to our 16-in. 3-high mill which breaks down 3 x 3 billets to sizes that can be taken by our 12-in. and 10-in. Belgian rod mills. Brinell tests were again made and the heaviest neck load found to be 96,000 lbs., the mill speed being 112 r.p.m.

Housing limitations again precluded the possibility of using the original neck sizes and here we reduced them from 10½ in. to 10 in. but notwithstanding the fact that we robbed the roll necks to the limit, we could not get in the required capacity and finally used bearings that were rated at 73,000 lbs. at mill speed. These bearings are 10 in. x 14 in. x 8 in. This mill has now been rolling on this size bearing since March, 1926 and they have been subject to overload ever since. Power readings taken on the 16-in. mill for over a period of months show savings as high as from 34 per cent to 47 per cent as a regular occurrence, and savings as high as 62 per cent have been attained.

The pinion stand for this mill has also been equipped with the same size bearings but as the load on them is only that of tooth pressure, very little saving in power is noted but the maintenance and repair bills have all but disappeared. These bearings have required no attention for 18 months except for that of lubrication.

22-in. Mill Equipped

In September, 1927, we equipped our 22-in. 3-high roughing stand with bearings, and in order to put them on all three rolls, we had to reduce the necks to 12 in. diameter. The bearings used are 12 in. x 17½ in. x 9½ in. They are of the four row type and have a capacity of 163,000 lbs. at 60 r.p.m. This installation

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*Abstract of paper read before the Engineers Society of Western Pennsylvania, April 3, 1928.

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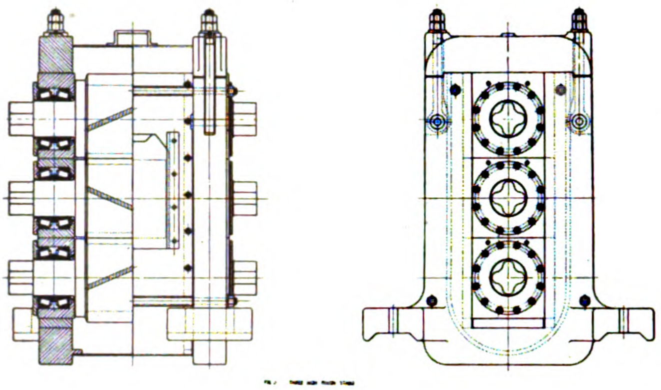

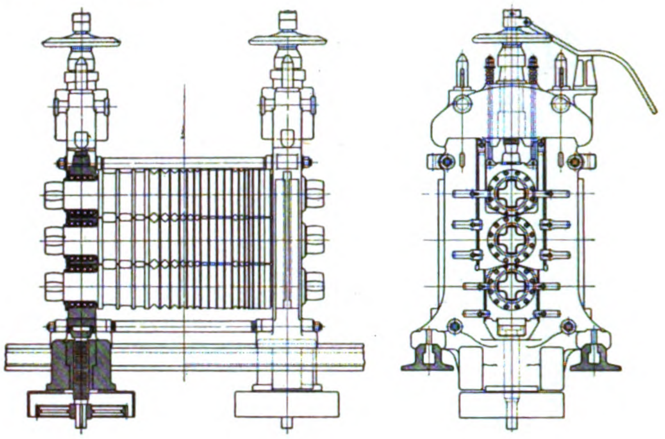

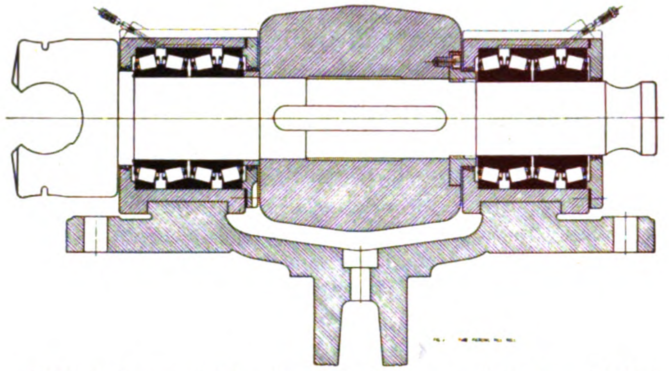

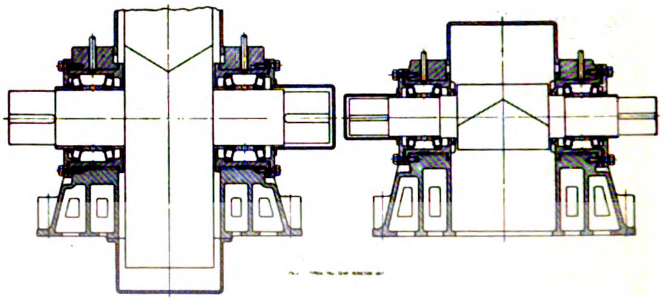

FIG. 1 (upper left)—Typical pinion stand design. FIG. 2 (upper right)—16-in. 3-high mill. FIG. 3 (lower left)—Mannesmann seamless tube piercing mill roll. FIG. 4 (lower right)—Typical gear reduction unit.

has been in service, and has required no attention since that time.

Our 10-in. 2-high rod finishing stand was also equipped with Timkens about 8 months ago, but due to a curtailment in our rolling operations this stand has not seen more than about one month's actual service. We are pleased to report however that we are able to roll rods held to a tolerance of plus or minus one and one-half to two thousandths on the diameter. The bearings are of the four row type, 5½ in. x 8¾ in. x 5 in., and have a capacity of 16,000 lbs. at 500 rpm.

Since placing our mill in operation several other companies have made similar installations on 2-high mills using the same or similar bearings. The bearings on one neck are fixed, while the one on the opposite neck are permitted to float. This construction was adopted in order to insure a more positive alignment of the passes.

Bearings on Tube Mills

The main roll necks of our 26-in. Mannesmann seamless tube mill have also been equipped with our bearings. The bearings used on the drive end are 7 in. x 12 in. x 9¼ in., and those on the free end are 6¼ in. x 12 in. x 9¼ in. The loads on these bearings were obtained by means of a Brinell test while piercing 6-in. rounds 75 in. long to tubes with 4½-in. holes and 25/32-in. walls. The steel was 4615 S.A.E. and the blank weighed 600 lbs. The loads encountered were 81,000 lbs. and 71,000 lbs. respectively on the drive and free ends.

This mill has been in operation on Timkens for approximately six months, and has since then more than paid for the bearings. This application was practically forced upon us by our operating department because the extremely heavy duty incident to piercing alloy and high carbon tubes entailed an outlay of about $12,000 per year for plain bearing upkeep.

We hope in the near future to be able to give the industry some interesting facts concerning power consumption on plain bearings, and the savings effected through the use of roller bearings. We have been engaged in taking power readings since last November, but due to the diversified sizes and analyses handled, we have not been able to accumulate sufficient comparative readings to permit publishing our results.

Before leaving the subject of our personal experience with the application of bearings in our mills, it will interest you to learn that we have already made bearings, and have machined the rolls for a complete change-over on our 35-in. 3-high blooming mill. The change-over is being held up until we shut down our plant to tie up our present mills with the addition of an 18-in. to 8 in. continuous merchant mill, 28-in. 3-high breakdown and 22-in. bar mill which we are installing this year. In this connection, we can advise that the new rolling equipment in its entirety will run on Timken bearings.

4-High Mills

Leaving the discussion of the experience we had in our own plant, and taking up the question of anti-friction applications in 4-high mills, we can advise that at present the following installations are rolling on our bearings:

Four stands of 4-high cold strip mills.
Six stands of 4-high cold strip mills.
Four stands of cluster type cold strip mills and
One stand of 18-in. 2-high finishing mill
One stand of cluster type cold strip mill.
One stand of 4-high hot strip mill.

The bulk of the success so far enjoyed with 4-high mills can without doubt be laid to the fact that roller bearings are used on the necks of the back-up rolls. The belief now also prevails that the use of such bearings on the necks of the working rolls will become general in a short time. Whether their utility in this location lies in their anti-friction quality or in that of keeping the rolls in better alignment is still a matter of dispute, and only time will disclose which quality has the greater merit.

The first requirement of a roller bearing for the back-up rolls is of course that of capacity, the second that of its being almost frictionless. So far as we know, there is no generally known method for calculating the loads that must be carried by the bearings, but now that several 4-high installations are successfully rolling sheets, this problem has become a simple one in that tests can be made under actual rolling conditions to accurately determine the loads that are being taken, and applying the results to later designs.

We made a pressure test in one of the above 4-high cold mill installations in which 17 in. x 26½ in. x 13½ in. four row bearings are used. These bearings are designed for 1,000,000 lbs. at 10 r.p.m. The test was made while one stand was rolling 37¼-in. and 38½-in. wide sheets. The former were of .10 carbon steel, and the latter were alloy, both steels were unannealed. The carbon sheets were .084 in. thick before and .073 in. after rolling, the reduction being 13.1 per cent. The neck loads recorded were 750,000 lbs. and 724,000 lbs. respectively.

The alloy sheets were .114 in. thick before, and .099 in. after rolling the reduction again being 13.1 per cent, and the neck loads were 803,000 lbs. and 757,000 lbs.

In another installation where 18 in. x 28¾ in. x 14¾ in. bearings were used on the back-up rolls we made the test, while 40-in. wide .12 carbon sheets were rolled. The reduction made was from .075 in. to .054 in. or 29 per cent. The speed of the back-up rolls was 20 r.p.m. and the loads recorded 1,200,000 lbs. and 1,082,000 lbs. respectively.

It will also be interesting to learn the results of a test we made on a 4-high hot strip mill while 5⅞ in. wide .093 in. thick, the reduction being 16.6 per cent. The steel was of approximately .12 carbon, and the neck load while rolling was 130,000 lbs. Our bearings are 10 in. x 17 in. x 11¾ in. four row and they were going at 275 r.p.m. The capacity of these bearings at that speed is 175,000 lbs.

Life from Anti-Friction Bearings

We are repeatedly asked what life can be expected from the anti-friction bearings on the roll necks. In view of the short experience so far had with bearings in actual operation this question is difficult to answer. We can however say from observations made for a period of over a year that very little wear is shown in that time.

We have made it a practice, when installing new bearings in mills, to make a complete record of the bearing fits and the adjustment used when they are set up. This gives us a very close check on the actual amount of wear. In one instance, where the bearings were in operation for over 13 months on the necks of cluster mills, we could not remove a .015-in. shim, this being the thinnest used when the first set-up was made. This shows that the wear must have been considerably under this figure, and leads us to believe that the bearings will operate under these conditions for a period of two years before any adjustment will be required. We are fortunate in having access to the above mills at any time, and intend to keep up our periodical inspections in order to get exact data on bearing wear and life.

The question of the cost of maintenance and possible power savings from the use of anti-frictions on roll necks is also continually brought up. We can only cite our own experience in checking such costs on our 16-in. mill. With plain bearings in this mill, our monthly outlay for grease, babbitt and labor on repairs amounted to $66 per month, and the cost that can be applied against Timken bearings since they are in operation has amounted to only $2 per month, and that for lubrication. The $66 mentioned above does not include cost of labor for changing the bearings during mill set-ups.

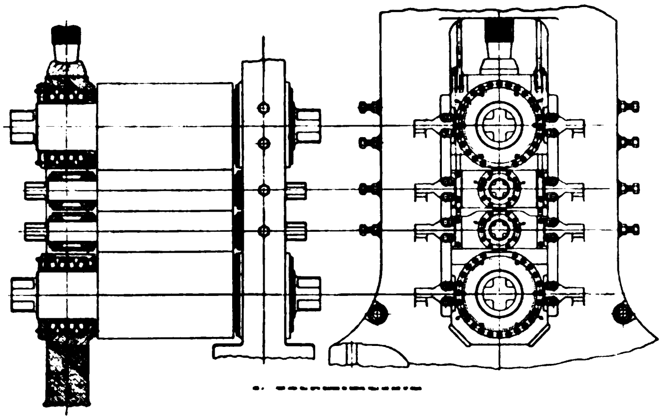

FIG. 5—Typical 4-high mill design.

As regards the power cost for this mill, our records show that for a period of one year the cost when rolling on plain bearings was $12,000 as against $6400 on Timkens. This shows a saving of $5600. The cost of making this installation was a little more than $3000 which shows that it took about 7 months' time to pay for the bearings with power savings alone.

Lubrication of Bearings

Our lubrication engineer has made careful studies of the proper method of lubricating our bearings, and recommends the use of either oil or grease. His specifications for grease are that it should be made of a good grade of cylinder stock oil having a viscosity of not less than 1500 seconds at 100 deg. F. Universal Saybolt. Sufficient grease should at all times be supplied to the bearing boxes to insure protection to the bearings by preventing the infiltration of water and scale. This, of course, requires the use of proper bearing closures on the boxes.

Before leaving the discussion of actual installations and offering a list of mills now using our bearings, we believe that a short reference should be made to the method used when gear drives and pinion stands are equipped with anti-frictions. The application con-

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sists of only a two-row bearing for each neck, as contrasted with the type used in our 16-in. mill pinions. The use of the two-row bearing permits of a more compact design and should appeal to builders of such equipment. We have found that the loads on the pinions are light as compared with the roll neck loads and that a two-row bearing of the same design as is used on the roll neck will answer all requirements and will to a large extent simplify the building, and also the maintenance, of such stands.

In order to simplify the problems of the design for all manufacturers of these units, and to insure properly designed units for all installations, we have adopted the policy of figuring all mill gear drives for an overload capacity of 200 per cent. This factor of safety, combined with the inherent factor of safety in the bearings themselves will amply take care of the overloads encountered from possible spindle breakages, and the indeterminate unbalanced loads due to the flywheel effects on the pinions where fly-wheels are used.

In conclusion we might state that with the exception of the work done at our own plant, most of the applications have been made on new mills. In existing cold mills, we have found that neck diameters are very large, and it is impossible to incorporate antifrictions unless a corresponding increase is made in the body diameter of the rolls. In existing hot mills, we have to consider the problems of high temperatures, and the impact due to the jump of the top rolls. On new mills this problem can be effectively worked out, and we are prepared to co-operate with any mill builder who has such problems under consideration.

On guide mills, the application of bearings can generally be accomplished without much difficulty in 2-high mills, but in 3-highs, space limitations are against us unless roll centers are increased or neck diameters are reduced, to permit of working in middle chocks with sufficient metal on the outside of the bearings to take the loads coming down on them. It is also a difficult task to convince the mill operator that roll necks can be reduced when roller bearings are used, but now that we have a number of mills operating on reduced necks, we believe that experience will eventually demonstrate that a smaller neck can be safely used with roller bearings than is considered practical today with the old style of plain bearing.

Up to the time of writing this paper, the following roller bearing installations have been made by my company outside of its own plant:

No. of stands	Installation
3	52 in. Universal beam mills
4	4-high cold strip mills
1	2-high 18 in. cold strip mill
4	Cold strip cluster mills with pinion and gear drive
1	4-high cold strip mill
1	Cold strip cluster mill
6	4-high cold strip mills
2	Edging mills
1	Edging mill
3	Edging mills
	Expanding mill thrust blocks
1	4-high hot sheet mills
2	4-high hot strip mills
1	30 in. lap weld pipe mill
2	20 in. copper rod rolling mills with pinion stands
9	12 in. copper rod rolling mills with pinion stands
1	13 in. 3-high rod mill pinion stands
2	10 in. 2-high bar mills finishing stands

Republic Iron & Steel Company Management Undergoes Change

An extensive modification of the policy of the company is made evident in the appointment of several officials, from other companies, to positions from which control is exercised.

As now constituted the reorganized executive staff of the company is John A. Topping, chairman of the board; Elmer T. McCleary, president; Harry L. Rownd, vice president; Harry T. Gilbert, vice president in charge of sales; John U. Anderson, treasurer. Mr. McCleary and Mr. Gilbert, together with Mr. John T. Harrington of the Trumbull Steel Company, were also placed on the board of directors.

Mr. McCleary, who succeeds Mr. Thomas J. Bray as president, has been with the Youngstown Sheet & Tube Company since 1907. He was graduated from the Pennsylvania State College in 1901 and for some years was an employe of the Diamond State Steel Company of Wilmington, Del., and the Ohio Works of the Carnegie Steel Company. While with the Youngstown Sheet & Tube Company, McCleary advanced from the position of chief chemist to that of vice president in charge of production.

Mr. Gilbert has served in the sales department of the Sharon Steel Hoop Company since 1906. In 1919 he was elected vice president in charge of sales.

Mr. Anderson was for about 10 years treasurer of the Trumbull Steel Company, and held that position at the time the Trumbull Steel Company was absorbed by the Republic Iron & Steel Company.

Foremen to Hold Convention

The fifth annual convention of the National Association of Foremen will be held in Canton, Ohio, on Friday and Saturday, May 25 and 26. A very extensive program has been planned for the convention, which includes addresses by several men of national importance in industrial affairs, and visits to several industrial plants in Canton and its immediate neighborhood. As to the latter, plans have been made for visits to the Massillon, Ohio, plant of the Central Alloy Steel Corporation, the plant of the Hoover Company, manufacturers of electric cleaners at North Canton, the Pennsylvania Railroad Shops, and the plant of the Timken Roller Bearing Company in Canton.

The list of speakers and their subjects for the first day includes, Mr. F. A. Seiberling, president of the Seiberling Rubber Company and founder of the Goodyear Tire & Rubber Company, who will speak on the subject: "The Requisites of the Foremen of Tomorrow," Mr. A. B. Segur on "Conservation of Man Power Through Motion Analysis," and Mr. W. Chattin Wetherill of the University of Pennsylvania on "Industrial Waste." After the close of the day's meeting there will be a banquet, and entertainment, after which the meeting will be re-convened for the introduction of the new officers and address by Mr. H. W. Hoover, president of the Hoover Company of Canton, Canada and England.

The speakers for the second day, will be Mr. J. C. Wright, director of the Federal Board for Vocational Education, on the subject of "Foremen Conferences," and Mr. Robert H. Spahr of the U. S. Chamber of Commerce on "The Foreman as an Executive."

Gas Analysis Index to Furnace Operation[*]

An Abstract of Work in Germany Toward the Evaluation of the Blast Furnace Gas Analysis in Terms of the Operating Conditions of the Furnace

By G. V. SLOTTMAN[†]

IN firing boilers and furnaces in which the charge to be heated does not come in direct contact with the gases of combustion, the conditions of combustion can be readily controlled from a knowledge of the analysis of the flue gases. The increasing number of continuous CO_2 recorders to be found in boiler houses where value is placed on efficient operation, evinces the rapidity with which plant operators have come to recognize the interdependence of flue gas composition and quality of combustion. With the aid of the flue gas analysis alone, the operator is able to judge the instantaneous operating characteristics of his boilers. In the case of lime and cement kilns or blast furnaces, where the gases evolving from the charge mingle with and dilute the gases of combustion, the simple relations applying to boilers no longer hold. It becomes increasingly difficult to draw conclusions as to the actual operating conditions from an analysis of the waste gases.

The number of reactions veiling the actual combustion reactions in the blast furnace is especially large. A short distance above the tuyeres, the gas is essentially a mixture of CO and N_2 with a small amount of H_2 from decomposed water vapor. As the gas rises in the shaft, the following reactions, charging the gas analysis, can take place:

1—$CO + \frac{1}{2} O_2 = CO_2$ indirect reduction of ore.

2—$C + \frac{1}{2} O = CO_2$ direct reduction of ore.

3—$2 CO = CO_2 + C$ deposition of carbon.

4—$CO_2 + Fe = CO + FeO$ oxidation of the scrap.

5—$CaCO_3 = CaO + CO_2$ calcination of limestone.

6—Vaporization of water in the charge.

7—Reactions of minor importance, viz., distillation of H_2 from coke, interaction of the several gas constituents, etc.

These reactions alter the composition of the gases to such an extent that, from their analysis at the charging bell, little can be said as to the actual conditions in the furnace. The gas analysis, however, represents the single external characteristic by means of which the state of the furnace can be immediately determined. (Pig temperature and analysis, slag viscosity and similar factors show conditions prevailing some hours previous to the time of their determination.) The evaluation of the gas analysis in terms of the instantaneous rate of coke consumption and of ore reduction would enable the operator to overcome his present difficulty resulting from the fact that measures to correct a bad condition can only be taken after that condition has existed for a considerable time in the furnace. It would place in his hands the same tool which the boiler operator is using to such good effect.

Bansen's Method

Bansen has recently proposed a practical method for calculating instantaneous heat and material balances from a knowledge of the gas analysis and of the volume of air blast. This method consists, essentially, in the reduction of the gas analysis as performed in the usual manner, to a basis of the actual combustion reactions. The primary diluent of the products of combustion is the CO_2 evolved from the limestone, (the H_2 and N_2 from the coke being of secondary importance.) By subtracting the carbon equivalent of this CO_2 from the total mols of carbon leaving the furnace, it is possible to set up a heat balance which will show the instantaneous disposition of the carbon charged as coke to the furnace, among the various reactions into which it enters. The means are then at hand for calculating the rate at which coke is burning at the tuyeres and the rate at which heat is being supplied. At the same time the rate of ore reduction may be calculated and a balance thus made between the heat available and the heat required for the various metallurgical purposes. Any discrepancy in this calculation is an indication that the furnace is not functioning properly. In the actual application of this method, the above mentioned calculations, once made for a particular furnace and charge, need not be repeated for each analysis. A particular analysis may be taken as the norm of proper operation. From the deviations of the following analysis from this standard, the nature of the disturbance, be it carbon deposition with the intendent danger of the furnace's hanging, increased direct reduction or oxidation of the scrap by CO_2, can be ascertained at the moment that the irregularity occurs. Corrective measures, applied at this time, will limit the extent to which these disturbances will have otherwise magnified themselves if allowed to proceed unchecked to the point where the operation of the furnace with normal output becomes impossible.

To be sure, the procedure outlined above is at present in the experimental stage. Insufficient data have been collected to allow of the prediction of the extent to which simultaneously occurring disturbances influence the composition of the gases. However, the far-seeing operator must realize the present inadequacy of his methods of control and the wholly empirical nature of the art of producing pig iron from ore. In the gas analysis and its conversion into terms of furnace operation, lies the only possible means at his command for the scientific regulation of the blast furnace process.

Bansen's Factors

From a long series of experiments on blast furnaces operating under different conditions of blast temperature, gas temperature, etc., Bansen has calculated the effects of these factors on the coke consumption per ton of pig iron. His results, while applying directly to German practice, show the relative importance of the various factors influencing the consumption in terms of American practice. Table I includes a series of factors, variations in which to the degree noted cause a ± 20 lb. per ton change in the amount of coke needed.

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[*] Abstracted from Bericht No. 86 des Hochofenausschusses des Vereins deutsche Eisenhuettenleute. (Die Beurteilung der Stoff und Waermebilanz des Hochofens nach der Gichtgas analyse und der Windmenge) Dr. Ing. Hugo Bansen.

[†] Director of the Buffalo Station of the Massachusetts Institute of Technology, School of Chemical Engineering Practice, Bethlehem Steel Company, Lackawanna, N. Y.

As can be readily seen from the above tabulation, the influence of changing gas and air temperatures greatly exceeds that of the other factors. A 50 deg. F. increase in the blast temperature decreases the coke used per ton of iron by 20 lbs. Since periodic variations in the blast temperature to a considerably greater extent are common in actual practice, a corresponding uncertainty as to the amount of coke to be charged must exist. In a similar manner, the magnitude and direction of the influence of the other variables tabulated can be calculated and the saving in coke to be affected by changes in the several operating conditions approximated.

TABLE I

Factor	A change in this factor indicated below varies the lb. coke/ton of iron by 20 lbs.
Pig iron temperature	250 deg. F.
Slag temperature	210 deg. F.
Blast temperature	50 deg. F.
Gas temperature	37 deg. F.
Increase in production	13 per cent
Moisture in gas	4.2 grains/cu. ft.
Scrap/ton of iron	8.3 per cent
Slag/ton of iron	52.0 lbs./ton
Moisture in ore and stone	1.7 per cent
Manganese in pig	1.2 per cent
Carbon in pig	0.8 per cent
Preheating coke	130 deg. F.
Moisture in coke	0.65 per cent
Ash in coke	0.62 per cent
CO in gas	0.53 per cent
Preheating ore and stone	81 deg. F.
Phosphorus in pig	0.40 per cent
Silicon in pig	0.30 per cent
H_2 in gas	0.27 per cent
CO_2 from CO (indirect reduction)	0.25 per cent
CO_2 from C (direct reduction)	0.17 per cent

H. D. Savage, President Combustion Engineering Corporation

George E. Learnard, president of International Combustion Engineering Corporation, 200 Madison Avenue, New York, announces the resignation of Joseph V. Santry as president of Combustion Engineering Corporation, an American subsidiary of International Combustion Engineering Corporation, and the election of H. D. Savage, for many years vice president, as president to succeed Mr. Santry.

George T. Ladd has been elected vice chairman of the board of directors of Combustion Engineering Corporation.

Mr. Ladd is an authority in the design and manufacture of steam boilers, and has achieved marked success in this field, especially in connection with large units such as those installed at the Fordson plant of the Ford Motor Company, the Kip's Bay Station of the New York Steam Corporation, and a number of prominent stations abroad. Mr. Ladd is president of the Ladd Water Tube Boiler Company and president of the Heine Boiler Company.

Mr. Savage brings to his new office a long and varied experience in the manufacture and sale of power plant equipment. He has been identified with the development of pulverized fuel burning equipment since its very inception and is recognized as an authority on this subject. In 1916 he became vice president of the Locomotive Pulverized Fuel Company. When the Combustion Engineering Corporation purchased the Lopulco Pulverized Fuel Systems in 1920, Mr. Savage became associated with this organization as the directing head of the Pulverized Fuel Division.

In addition to the presidency of Combustion Engineering Corporation, Mr. Savage holds the following offices in subsidiary companies of International Combustion Engineering Corporation: President, Dry Quenching Equipment Corporation; president, Combustion Engineering Corporation, Ltd., of Canada; vice president, Ladd Water Tube Boiler Company; and vice president, Raymond Brothers Impact Pulverizer Company. Mr. Savage is a member of the American Society of Mechanical Engineers, American Society of Mining and Metallurgical Engineers, Franklin Institute, and is the author of numerous papers and technical articles.

H. D. Savage

George T. Ladd

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Sheet Steel for Automobile Bodies

A Metallurgical Study of the Low Carbon Grade of Steel that Is Used for Sheets—Critical Points and Transformations—Banded Structure—Grain Growth

"AUTOSHEET"

PART III

WE have now reached a point where it would be well to briefly explain the occurrence, cause and effect of the various constituents of the steel. These constituents and their physical properties will decidedly influence the method of annealing the sheets after they are rolled to size and for this reason we shall more thoroughly understand the forthcoming annealing information and the structures illustrated by microphotographs, if we are presented with the facts of their existence.

We are primarily interested in producing, from a low carbon sheet, the maximum softness or ductility possible for making difficult stampings without breakage yet the material must have such strength as to stiffen the sheet, thus making automobile body parts such as fenders, strong enough to resist road shock without reinforcing. In addition to these requirements the grain structure or size of iron crystals of the final sheet must be small in order to present a smooth surface after drawing, for painting and general body appearance. All of these factors combined represent the maximum care in the refinement of sheets thus making the sheet industry, especially when serving the automobile trade, most exacting.

The demand for all of these finishing properties requires unusual care in the softening of the sheet through normalizing or annealing without enlarging the grain to any marked extent and a careful control of its cold rolling for strength and surface finish without impairing its physical properties. It is, therefore, logical that, before going further in the processing, we discuss, as briefly as possible, such factors as will later help us to decide the best treatment for the maximum refinement of the sheet.

Sheet steel is a complex product composed of many chemical elements held either mechanically or chemically as mixtures or compounds in a solid mass of iron. In our low carbon steel we have such elements as carbon, manganese, phosphorus, sulphur, silicon, aluminum and dissolved oxygen, with traces of nitrogen and hydrogen. All of these elements are considered as impurities except carbon and manganese which are very beneficial to the physical properties of the steel. As manganese is absorbed in the iron to a point where its distribution and presence cannot be microscopically determined and chemically only in a quantative sense, we shall consider carbon as our only factor or element which will influence the physical and microscopical properties of low carbon sheet steels. The only practical exception to this is a very low carbon and manganese steel which presents a special auto body sheet requiring mention at a later point.

Carbon in a solid solution of iron combines with it to form carbide (Fe_3C) which in itself is very brittle and hard and is known as "cementite." This "cementite" in turn combines with iron to form a mechanical mixture called "pearlite" while the excessive amount of iron crystallizes into grains called "ferrite." These are revealed by means of polishing a small section of the sheet and then etching this section with weak acids which affect these constituents in different ways. This etched section is then placed under a microscope of high magnification (usually 100 diameters) and the structure containing varying amounts of these constituents examined, which, as will be explained shortly, vary with the carbon content.

Microstructural Constituents

"Ferrite" is the term applied to crystals of pure or carbonless iron and in the case of sheet steels we usually have an excessive amount present. To distinguish this form such ferrite which combines with cementite (Fe_3C) we will refer to it as "excessive" or "structurally free" ferrite.

This excessive ferrite is very soft and ductile, imparts no hardening power to the sheets under ordinary conditions of slow heating and cooling, has an ultimate tensile strength of 38,000-40,000 lbs. per sq. in., an elongation, in an 8 in. test strip, of 30-32 per cent, a Rockwell hardness around B-20-B-25, and a Brinell hardness of about 80.0. These factors lead us at once to assume that the majority of sheet steels run as high as commercially possible in ferrite, which is true. Polished and etched with dilute 5 per cent nitric or picric acid in alcohol it appears as white grains as illustrated in Fig. 1, magnified 100 times. The crystals of iron which appear shaded are due to the orientation ot the crystal which sets at another angle from the majority of crystals appearing in the microphoto. This angle reflects the light at the same angle at which the crystal sets thus making it appear dark.

"Cementite" is found in slowly cooled steels as Fe_3C. As we have previously stated carbon and iron are the essential ingredients of sheet steel and in a slowly cooled steel containing less than .85 per cent carbon we find it all combined with the iron to form Fe_3C which contains 6.67 per cent carbon and 93.33 per cent iron by weight with the remaining iron existing in the steel as free ferrite previously explained.

Cementite is extremely hard and brittle and in fact is the hardest of all constituents of steel, having no elongation and a Brinell hardness between 600-700. Polished and etched with dilute acids it appears under the microscope brilliantly white. Fig. 2 shows a .90 per cent carbon steel magnified 400 times, in which the slight excess of cementite present remains white and practically unetched surrounded by pearlite (Fe_3C plus ferrite) etched to a point of appearing dark.

In sheet steel whose practical carbon range runs from .03 per cent to .15 per cent the cementite is usually mechanically combined with the excessive ferrite present to form a conglomerate called "pearlite." This formation of pearlite requires a brief explanation as it is to be mentioned a great many times along with ferrite in the structural study of sheet steel. In the slow cooling of a steel from a high temperature which we will place around 1850 deg. F. the carbon first combines with iron to form cementite (Fe_3C). This formation of cementite throughout the solution is naturally thoroughly intersperced with the iron or ferrite and stratifies with it, and as the steel passes through the temperature range of 1270-1320 deg. F., a definite proportion of the free ferrite has precipitated leaving cementite and ferrite. These two constituents being in a definite proportion or eutectoid form mechanically combine in layers in the proportion of seven parts of ferrite to one part of cementite at this temperature.

This stratified mixture is immediately converted within this temperature range to "pearlite" the name being derived from the fact that under an oblique light it shows a display of color suggestive of Mother-of-Pearl. So far as we are concerned it appears as a dark or black constituent when the polished sheet is etched with dilute alcoholic acids under the usual magnification of 100 diameters as illustrated by Fig. 3 (picric acid etch for this plate). To bring out more clearly this striated or distinctly laminated structure of pearlite it is necessary to magnify to a high degree this constituent. Fig. 4 clearly illustrates this constituent as mignified 600 times and etched with weak nitric acid. The carbide or Fe_3C plates remain white as their unusual hardness does not permit ready etching with weak acid. The ferrite or pure iron plates appear dark due to their softness and being depressed slightly below the level of the carbide plates do not reflect the light together with the fact that a slightly longer etch has tarnished them.

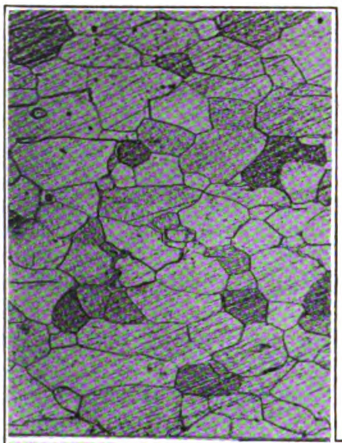


FIG. 1 (upper)—Ferrite grains. 100X.

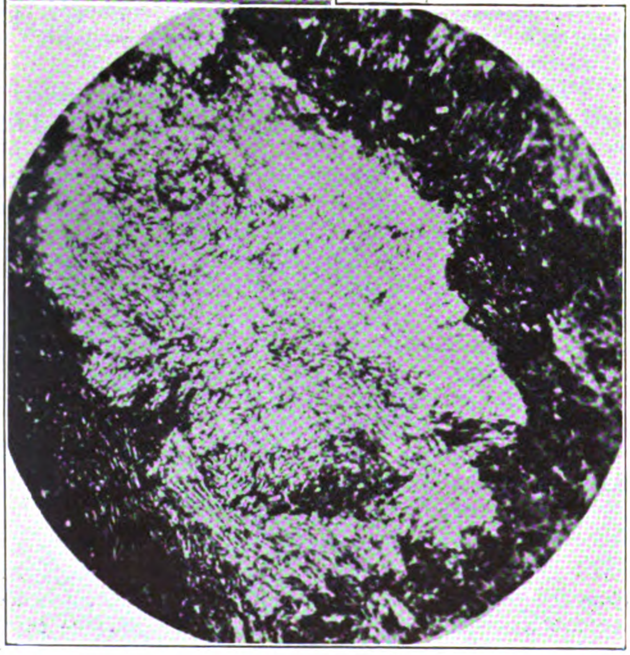
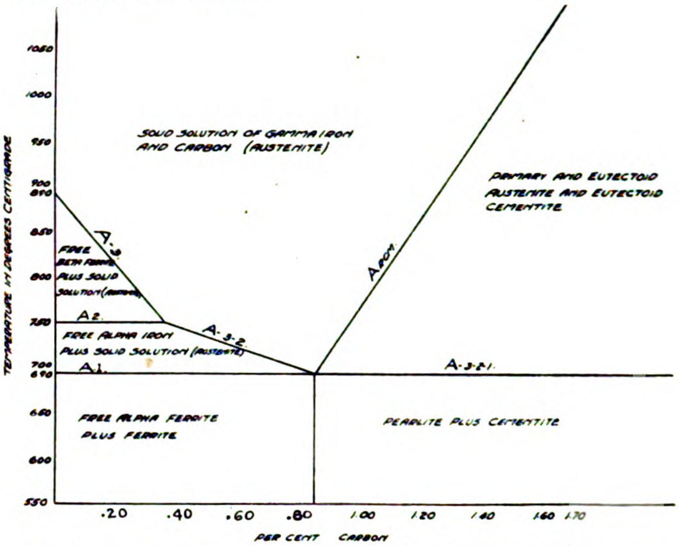


FIG. 2 (lower) — Cementite. 400X.



Graph I—Showing critical ranges for slowly cooled steels of varying carbon content.

This pearlitic formation is often referred to as an "eutectoid" for it exists in a definite proportion within the commercial range of carbon steels, always containing .85 per cent carbon. Pearlite is not always laminated as we have described, but will vary from ill defined and granular forms to laminated structure depending on the temperature the steel reaches before cooling, rate of cooling and the amount of cementite and ferrite present.

Normal pearlite gives strength to sheet steel and as it varies in proportion to the amount of carbon present one can readily understand the need of holding the carbon content of sheet steels to within definite ranges. Pearlite has a maximum tensile strength of 105,000 to 120,000 lbs. per sq. in., an elongation of about 10 per cent in 2 in. with a Brinell hardness of about 200.

Its appearance as illustrated in Fig. 3 as grains allows us to compute with fair accuracy the amount of carbon present in the steel by studying the microscopical structure.

Iron Carbon Diagram and Its Importance

With a meager knowledge of the microscopical appearance and physical properties which ferrite, cementite and pearlite possess we shall next briefly outline their formation by studying the iron-carbon diagram for steel or Graph I. This diagram represents the formation of the various constituents of steel up to 1.7 per cent carbon which we will consider as the practical working range for steels.

Sheet steels with a carbon range of .03-15 per cent carbon occupy a small portion of this diagram and while another graph showing an enlarged portion of this section of the diagram will be introduced later, we believe a better knowledge of steel constituents in general will be derived from a brief study of Graph I.

Thermal Critical Points

It has been observed and conclusively proven that steel of various carbon contents when heated to a point, say 1850 deg. F., and allowed to cool slowly show that the temperature of the steel is for the mo-

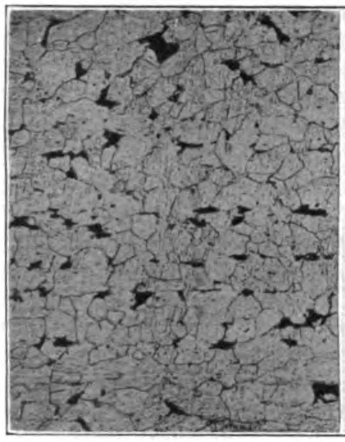


FIG. 3—Low carbon steel, dark portions are pearlite, 100X.

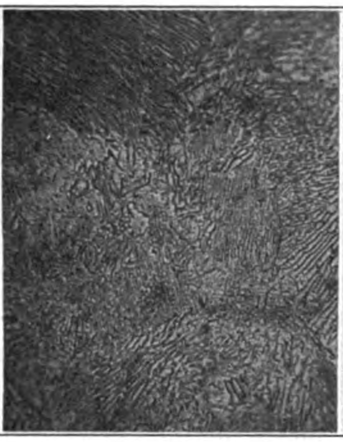


FIG. 4—Steel of .85 carbon, pearlite. 600X.

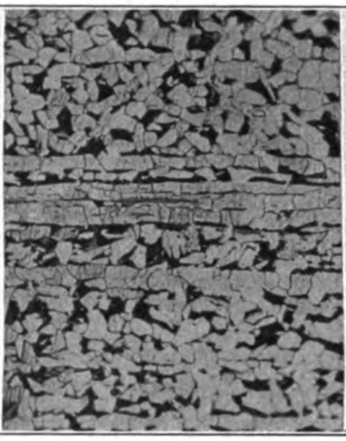


FIG. 5—Steel of .11 carbon in longitudinal section showing banded structure. 100X.

FIG. 6—Steel from finished sheet showing banded structure. 100X.

ment arrested in its dispersement which up to this particular point has been cooling at a uniformly retarded rate. This is recorded by sensitive pyrometers which, furthermore, show that after this slight pause the steel then continues cooling with one or two more pauses of less magnitude. This phenomena has revealed, by X-rays, the change from not only one constituent to another but its various forms allotropically known as alpha, beta and gamma iron.

For example, a steel of .85 per cent carbon heated to 1850 deg. F. and slowly cooled shows, by sensitive pyrometers, that at about 690 deg. -710 deg. C (1274 -1310 deg. F.) the steel not only fails to lose heat, but will often show a slight rise in temperature. This is usually called the point of recalescence and is practically good for steel only of this carbon content. The steel then cools to atmospheric temperature without further evolution of heat.

Let us now take a carbonless iron heated to the same temperature and slowly cooled. At a point approximating 900 deg. C (1652 deg. F.) a decided retardation in cooling is noticed followed by normal cooling to a point around 750 deg. C. (1382 deg. F.) where a second evolution of heat within the metal is noticed but which is not so pronounced. The metal then cools to atmospheric or room temperature without further heat changes.

Thus in a carbonless iron we have two points called thermal critical or simply "critical points" and only one critical point for an .85 per cent carbon. Let us take a piece of sheet steel of .10 per cent carbon and repeat the same experiment. The cooling from 1850 deg. F. is normal to a point between 830-860 deg. C. (1526-1580 deg. F.) where a marked heat retardation is noted, cooling then continues and two more thermal retardations of the steel are noted at 750 deg. C. (1382 deg. F.) and near 700 deg. C. (1292 deg. F.) both of which are very faint.

Thus we may conclude that we have in our sheet steels of .10 per cent carbon, three thermal points indicating one major and two minor readjustments within the steel as compared to one major adjustment for the .85 per cent carbon and a major and a minor adjustment for the carbonless iron.

If we carried this experiment out on steels of various carbon content we would find a graph similar to our Graph I. At a point where the carbon content was .35 per cent carbon we would find only two critical points, one at 750 deg. C. (1382 deg. F.) and the other at 700 deg. C. (1292 deg. F.) In specifying these critical points they have been approximate only but will serve our purpose. It might be well to mention that on heating the steel the critical point is between 20 to 40 deg. higher due to a "lag" or hysteresis loss and the slower the cool or heat the closer the heating and cooling criticals of any one carbon steel approach each other. Even the criticals on cooling vary within the same steel due to its chemical ingredients. temperature before cooling sets in and the time held at this temperature.

Laying aside these variables we will call these critical points or ranges A_1, A_2 and A_3 the sub-letter of 1, 2 and 3 indicating the first critical point on heating. Thus A_1 indicates the first critical point on heating the steel and so on. On second thought we should call these points Ar_1, Ar_2, and Ar_3, the small letter "r" being the abbreviation of the French word "refroidissement" which means cooling. Graphs similar to Graph I sometimes bear Ac_1, Ac_2 and Ac_3 in which the small letter "c" comes from the French "chauffage" meaning to heat.

However to simplify our graphs we will simply call them A_1, A_2 and A_3 which are sketched where the average of Ar_1 and Ac_1 are used as well as Ar_2-Ac_2 and Ar_3-Ac_3.

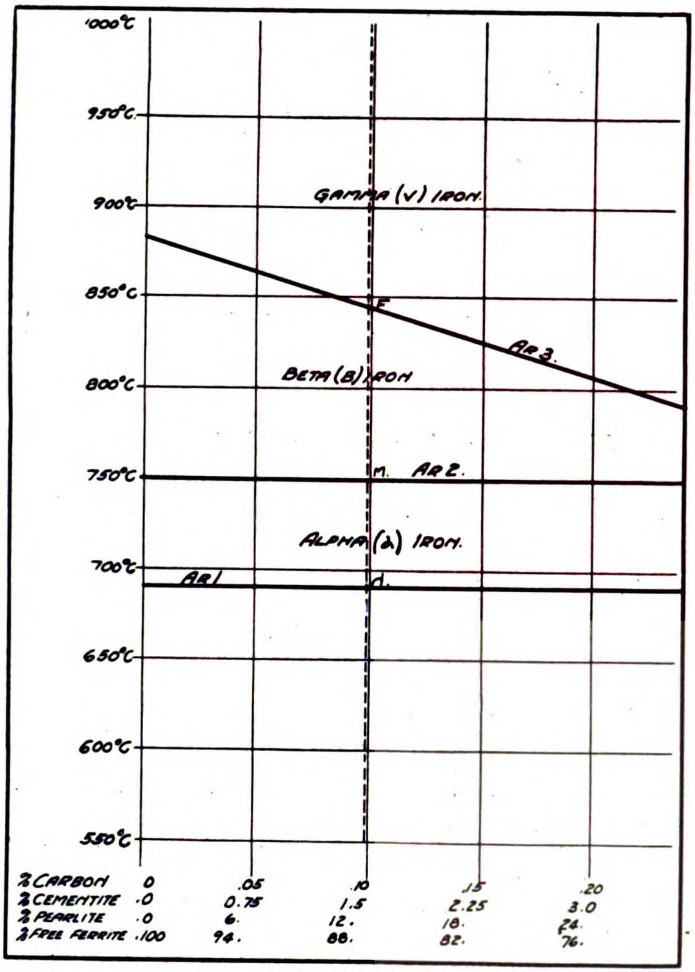
Cause of Critical Points

Changes Taking Place at A_3—These heat retardations at so called critical points have been thoroughly investigated by various authorities who, while differing on a few points, are in accord with the following changes as revealed by X-ray and microscopical analysis.

At the A_3 point which applies to steels of carbonless iron up to .35 per cent carbon we have a particular interest for it includes our range for sheet steels and warrants more detailed explanation. The A_3 point is the marked critical for this range of carbon and the expansion of the metal at this point is noted which is quite pronounced being about 1/1000 of its lienar unit of length.

Sensitive pyrometers not only record this dialation but at A_3 the electrical resistance of metal takes a sudden drop which, while a factor to be considered from a physical property standpoint, allows closer determinations for the critical point.

The recent use of the X-ray in studying the structure of metals has definitely shown that the evolution of heat at this point is due to a readjustment of the atoms of iron within the grain. In cooling the steel from 1850 deg. F. to A_3 the grains of iron were in a form similar to Graph III which is known as "gamma" iron being nothing more than a grain of iron with atoms of iron at each corner of the cube and one in the center of each face. This arrangement is also called a "face centered space lattice" which is self explanatory. Now by X-ray analysis we find that this heat evolution at A_3 is due to a readjustment of the atoms of this grain for we find that below A_3 we have a grain whose atoms of iron are distributed one to each corner of the cube and one to the center as illustrated in Graph IV. This is called "body centered space lattice" or "beta iron." Authorities differ as to whether this is beta or alpha iron at this point as alpha iron has the same atomic structure, but for the present we will consider it as a transition product—so it will remain "beta iron."



Graph II—Showing critical ranges for low carbon steels. (Sheet steel.)

The important change at A_3 critical point is the fact that the iron no longer holds the carbon in solution but begins to precipitate it as cementite (Fe_3C) along with the excess ferrite or free iron.

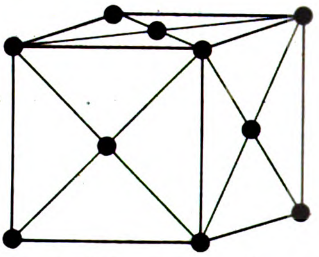
The further cooling of low carbon steels within 0-.35 per cent carbon range brings us to the A_2 or second critical point. Here we find a slight evolution of heat which indicates changes although less pronounced. An X-ray examination shows the atomic arrangement of the iron to be the same as that of the beta iron but which, for the distinguishing from beta iron of another critical range, we will call alpha iron. Thus at A_2 we have no atomic change, no expansion of the metal and no change in the dissolving power of iron for the carbon.

However below A_2 the steel becomes strongly magnetic, a continued precipitation of ferrite and if sufficient carbon a further precipitation of cementite.

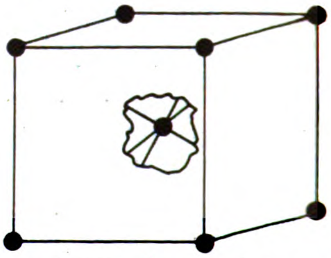
Further cooling then brings us to the A_1 critical point which not only exists for low carbons but for steels up to .85 per cent carbon as well. Such evolutions of heat as are noticed at this point are very pronounced near .90 per cent carbon and decrease as the carbon content is lowered. Thus for sheet steels we would find practically no A_1 point manifested by a heat change but only in its physical and microscopical state. The grains are body centered or "alpha" iron, the electrical resistance decreases and magnetism of the steel increases as the steel cools to atmospheric temperature.

Below this A_1 point the iron entirely loses its power for dissolving carbon which brings into play the major change for this critical point. Up to this point, from A_3 downward the carbon going out of solution gradually combines to form cementite and cementite with free ferrite. Now at A_1 we have the excessive ferrite all precipitated out of the solution leaving the remaining a eutectoid of cementite plus ferrite, which now precipitate in stratified layers of pearlite. The solid solution of carbon in iron is called "austenite" and exists in various forms (austenite is usually a solid solution of carbon in gamma iron; a solid solution of carbon in beta iron sometimes called "martensite;" a solid solution of carbon in alpha iron sometimes called "troostite" and then the eutectoid and the precipitation of "pearlite.")

To fill out an explanation for Graph I it will be noted that steels of .35-.85 per cent carbon have only two critical points A_{3-2} and A_1, the A_3 and A_2 being combined and bearing the various changes typical for these points. As previously explained at .85 per cent carbon we have one critical point A_{3-2-1} and the changes of all of these criticals take place at this point.



Graph III — Gamma iron of face-centered space lattice.



Graph IV — Beta and Alpha iron of body-centered space lattice.

Beyond .85 per cent carbon we have an excessive amount of Fe_3C present which precipitates along the line ArCM as free cementite in a matrix of pearlite. This explanation should suffice for high carbon steels and to better illustrate our own case let us examine more closely Graph II showing the critical ranges for low carbon sheet steels.

Up to this point we have discussed the:

(a) Occurrence and cause of the various critical points.

(b) Constituents forming at such points.

(c) Individual physical, chemical and microscopical properties of such constituents.

Therefore it would seem that our discussion of low carbon steels in this section would be properly concluded if we emphasize, in the study of Graph II, the ultimate physical and microscopical properties resulting from the changes which take place in slowly cooling a low carbon sheet steel of .10 per cent carbon content down to room temperature.

As we have mentioned above, Graph II represents the usual commercial range of sheet steels and while we rarely find the carbon content running over 0.15 per cent carbon the slight extension of the graph will serve to illustrate the downward trend of the upper critical A_3 point as the carbon content increases.

Solidification and Cooling

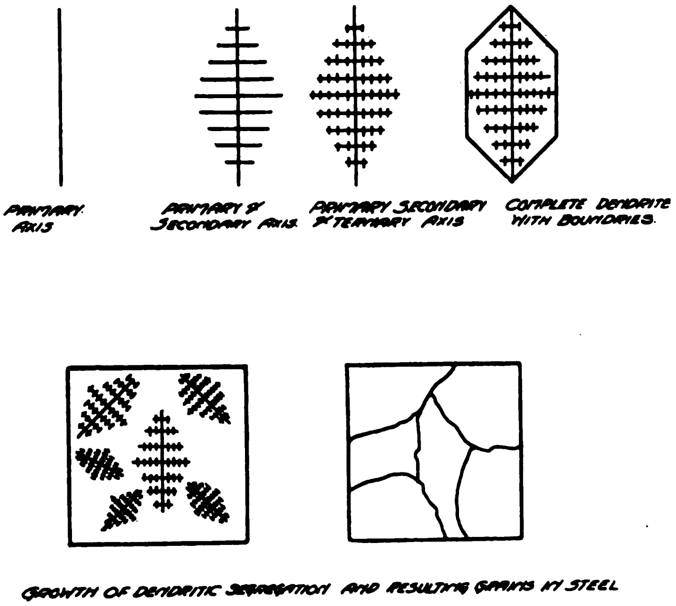
To best illustrate the slow cooling of our sheet steel let us start at the time when our steel is in a liquid condition in the mould. During the slow and undisturbed cooling of the ingot, crystallization of the molten steel begins from many nuclei, or centers, the majority starting at the wall of the retaining mould and working towards the center of the ingot. This primary crystallization takes place in a .10 per cent carbon steel at about 1500 deg. C. (2732 deg. F.) and causes the formation of primary austenite in "dentrites" which are crystallites developing in three directions corresponding to the axis of a cube. This formation as developed in Graph V, throws out similar branches and, providing the cooling is slow, form perfect cubes called "idiomorphic crystals." However it will be noted, from Graph V, that as these branches spread out and meet each other they distort some of the cubes which are called "allotromorphic crystals" or what we shall call "grains." These grains are also distorted by rapid cooling and the presence of foreign particles or impurities.

As this primary crystallization or dentritic formation continues and these branches or fine "fir tree" crystals continue to grow, they usually entrap such impurities as sulphides, phosphides and carbides which are last to solidify. Subsequent heating, such as annealing or normalizing usually distribute the carbides, but the sulphides and phosphides remain entrapped and undistributed. When the steel is rolled into blooms and bars the impurities within these branches of primary austenite are distorted along definite planes, forming so called "lamination" which is very detrimental in sheet steel. As reheating will not distribute or break up these planes of impurities they naturally will cause planes of weakness. Lamination may occur throughout the ingot but it is more common to find its worst condition near the top and center of the ingot and therefore considerable cropping at the bar mill is often necessary.

Banded Structure

Fig. 5 shows a longitudinal section of a low carbon heat (ladle analysis): Carbon .11 per cent, manganese .38 per cent, sulphur .034 per cent, phosphorus .020 per cent, which was taken from the first bar of sheet steel after cropping had been completed.

The impurities as well as the carbides have been entrapped between the branches of the cubes and caused their distortion along definite planes in rolling to bar size. Subsequent heating will distribute the carbide (dark areas) throughout the mass but the planes will more or less definitely remain due to the presence of impurities running through the middle of the microphotograph which hinder proper recrystallization. Therefore in our finished sheet we will still have banded or laminated areas (illustrated by Fig. 6) which upon drawing into auto body stampings, will split open the steel into layers similar to opening the pages of this magazine.


PRIMARY AXIS
PRIMARY & SECONDARY AXIS
PRIMARY SECONDARY & TERNARY AXIS
COMPLETE DENDRITE WITH BOUNDARIES.
GROWTH OF DENDRITIC SEGREGATION AND RESULTING GRAINS IN STEEL

Graph V—Crystalline growth and grain formation.

A closer scrutiny of Fig. 5 shows streaks of dove grey, manganese sulphide (MnS) elongated by rolling, which were primarily entrapped as globules between the branches of austenite.

This is better shown by an unetched picture of the same steel after polishing which show up the impurities in elongated dark areas. (See Fig. 7)

We have said that this banded or laminated structure is less pronounced in the middle or bottom of the ingot and as a general rule this is found to be true. Figs. 8 and 9 show unetched and etched sections as taken from the middle of the same ingot. From the study of Fig. 8, which is unetched, we find less inclusions than in the top of the ingot, but what are present run through the center of the bar or original ingot which substantiates the conclusion that the center and top of ingot are last to solidify.

The etched section of Fig. 8 is shown as Fig. 9 and indicates a slight tendency of the grains to laminate, but so insignificant that, after the proper heat treatment, practically no lamination will appear in the sheet.

All of these specimens have been magnified 100 times and the etched samples were attacked with a 5 per cent nitric acid.

Before leaving the discussion of lamination and the inclusion of impurities between the branches or dendrides let us etch with Stead's reagent. Fig. 5 which is the top of the ingot showing considerable lamination. Stead's reagent is essentially a copper chloride solution which shows up very decisively the variations in crystalline structure and the distribution of the sulphides and phosphides which cannot be detected by themselves in any of the above plates. This copper solution precipitates copper on portions rich in these impurities and appears dark under the microscope. Thus in Fig. 10 we have Fig. 5 re-etched with

FIG. 7 — Low carbon steel same as Fig. 5 but unetched showing inclusions. 100X.

FIG. 8 — Low carbon steel from middle of ingot unetched showing less inclusions. 100X.

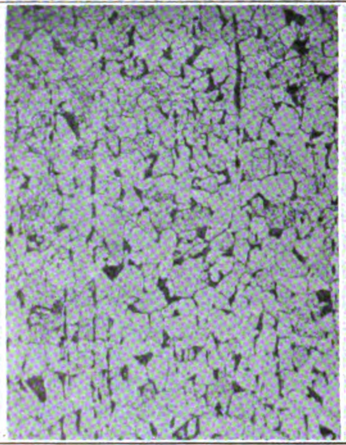


FIG. 9—Same specimen (Fig. 8) after etching. 100X.

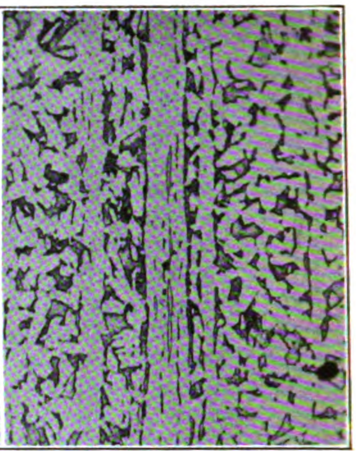


FIG. 10—Same as shown in Fig. 5, but etched to show inclusions. 100X.

Stead's reagent and the resulting dark sections indicate the areas rich in impurities which have been trapped between the so called "branches." In this comparison between Fig. 5 and 10 it is interesting to note the banded areas of ferrite with its inclusions between which are banded areas rich in impurities.

We have deviated from our discussion of the cooling of the metal but in doing so we have tried to emphasize, at this point, the formation of banded or laminated structures so common in sheet steels and which are the source of considerable press trouble. Many a press has been badly crippled by the splitting apart of a sheet in drawing and we do not believe this discussion is out of place or over-emphasized.

Grain Growth

In this dendritic formation of tree-like branches a very definite crystallization takes place and the cubes of iron, usually regular in shape, continue to form till the A_3 point is reached. Up to this point the grains have formed in a block like structure built up by a very definite arrangement of the iron atoms. If this arrangement met with no internal resistance we would have perfect grains but as mentioned above this is not usually the case for a practical cooling such as sheet steel ingots. Instead we have grains whose axis are usually at different angles. However, in certain portions of the ingot, we have little or no interference for perfect crystallization and a slow cooling usually allows the face of one grain or crystal to rest against the face of an adjacent crystal which permits the two crystals to combine thus causing so called "grain growth."

Slower cooling and purer metal have a tendency to aid this growth. Thus we can expect considerable grain growth in sheet steel low in carbon and in the various inclusions and impurities, which is slow in its cooling, after the heating of ingots or sheet bars and the annealing of the sheet. This presents a factor always to be contended with in the automobile sheet manufacture and will be discussed to considerable length in another section. For the present, however, we may expect considerable grain growth in steel after this crystallization sets in. This growth will continue till the upper critical A_3 point is reached, which for a .10 per cent carbon sheet steel will be at approximately 850 deg. C. (1562 deg. F.) or point "F" on Graph II. At this point the iron no longer has the power of holding carbon in solution and immediately begins to throw it out as cementite (FeC). In conjunction with this phenomena the crystals of iron change allotropically from gamma to beta iron or from a face centered to a body centered lattice. (See Graph III and IV). This will help to explain the carbon which, now free, has formed with iron to make Fe_3C. This release of carbon and atomic rearrangement causes considerable heat evolution as previously explained and the hardness of the steel is decreased as above A_3 the carbon has a hardening effect on the steel which is the prime factor in hardening by quenching but not of interest to us. Along with these changes at A_3 the ultimate tensile strength takes a decided drop but from A_3 to room temperature again gradually increases.

Thus at A_3 point grain growth stops, carbon begins to precipitate out in the form of cementite or Fe_3C, the steel loses its hardening power and the grains of iron change in atomic structure from gamma to beta form. As a continued cooling persists, the cementite continues to precipitate along with the rejection of free ferrite till the point A_2 is reached which is about 750 deg. C (1382 deg. F.) or point "M" on Graph II.

During this cool from A_3 to A_2 no grain growth takes place, the steel merely precipitates its cementite and ferrite and the tensile strength gradually increases from about 6,000 to 9,000 lbs. per sq. in. Now we reach, without further structural changes, the A_1 point where the beta form of iron changes to alpha which is also body centered.

Opinions differ as to whether there is such an allotropic form as beta iron but from the author's point of view let us consider beta iron as transitional only. The adjustment of the crystalline structure is also transitional between the A_3 and A_1 point and the accompanying physical properties such as increasing magnetism and decreasing electrical resistance go along with the increasing precipitation of structurally free ferrite and cementite all of which are increasing or decreasing in their magnitude. Allotropy, in a broad sense, is merely the modifying of the above properties without changing the iron's atomic structure or its chemical identity. Thus we pass through a transitory period and reach A_1 which is noted as "N" on our graph and occurs at about 700 deg. C. (1292 deg. F.) Our major change at this point is in the immediate

(Continued on page 640)

The Cleaning of Blast Furnace Gas*

A Comparison of the German Methods for Fine Cleaning—The Disintegrator and Its Operation—Bag Filter Systems—Electric Precipitation—Adaptibility of Methods to American Practice

By A. J. BOYNTON†

PART II

IT is natural that a progressive industry should have developed more than one system of gas washing. The first completely successful method developed for use in connection with the gas engine included pre-coolers or scrubbers in the shape of towers partly filled with wooden grill work and sprayed with water. Secondary cleaning was performed in the so-called drum type Theisen washer. The tower scrubber remains as an essential part of all wet washing systems. It is also used as an after cooler in connection with the bag filter system in order to reduce the temperature of the gas and so lower the maximum possible content of water vapor. In connection with the electrical precipitation system the scrubbing tower will in general be used both before and after the precipitator, although the occasion for its use will depend upon local circumstances with regard to the distance over which it is necessary to transport the gas.

The scrubber as used in Germany is characterized in many variations of detail. These include the extent and location of wooden grill work and the method of applying the spray. There is a disposition to locate the water sprays on the flat upper surface of the tower as is sometimes done in American benzol scrubbers. Generally speaking, the development of the cooling tower has been similar to the corresponding development in America and I know of no particular with regard to which the European scrubber is better than the American, in fact, the approved type of American scrubber probably effects a more intimate mixture of gas and water than do the scrubbers usually employed in Europe. This is natural, since the content of dust in the gas issuing from the scrubber is less vital in Europe than is the case in America where the scrubber has for most purposes constituted the entire washing system. Tower scrubbers equipped with rotating parts for the finer spraying of the water are not used in Europe, although the Feld washer of which numerous American installations have been made in recent years, is a European development. Continental practice, however, prefers the installation of rotating elements or other mechanical devices within a secondary washer.

Fine Cleaning by the Disintegrator

For purposes of fine cleaning the disintegrator came into general use as a secondary washer many years ago. For new installations it almost completely replaced the drum type Theisen and the water sprayed fan although the latter continues to be used in many locations. The construction of the drum type Theisen is well known in America in view of its practically universal adoption in American gas engine installations.

The disintegrator is a type of apparatus originally applied not to gas washing but to the fine crushing of coal and other materials for which purpose it had a very considerable development and a use which in some degree still continues. It consists essentially of a shell similar in general to the casing of a fan and provided with a rotating shaft on which is mounted a disc either centrally or at one side near the casing. The disc carries successive circular rows of bars which rotate rapidly between corresponding circular rows of bars fixed to the casing. The system is arranged to be sprayed with water in a fine state of division, the spray proceeding from points near the rotating shaft. The fine water spray is thrown uniformly into the space occupied by the rotating and stationary bars through which the gas is required to pass. The result is a complete wetting of the smallest particles of dust and the formation of globules of water of which the dust particle forms the nucleus, these globules being large and heavy enough so that their subsequent elimination from the stream of gas is easy.

The disintegrator is now practically always proceeded by a spray tower for cooling, although installations have been made in which the entire washing was performed within the disintegrator. This practice is extremely uneconomical on account of the fact that the water necessary to cool and clean the gas is approximately four times that required for cleaning alone. The horse power depends almost entirely upon the amount of water used within the machine, and there is an upper limit of water circulation beyond which the use of power becomes prohibitive. Under these circumstances the capacity of the disintegrator without previous cooling is about 25 per cent of that possible where pre-cooling is practiced. These circumstances have led to the practical abandonment of systems in which the entire cooling and washing process was carried on within the disintegrator.

Various types of disintegrator have been successfully used. The basic principle is similar in all cases and consists in the passage of mixture of gas and water between rapidly rotating and stationary bars. The total number of bars may be four or six. They may be of any desired cross-section and many variations in their shape were made in former years. The preferred construction is now the use of round bars as fixed members and of angle irons or "T" bars for the rotating elements. The clearances are quite close and the speed of rotation is practically as rapid as is consistent with a correct factor of safety in the design. An exception to this is found in the Schwartz-Bayer construction in which the two rows of bars rotate in opposite directions in separate cages instead of having one system of bars fixed. In this case the speed necessary to produce the same washing effect is one-half of the other. The construction, however, involves a double drive and the carrying of the disintegrator

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proper on overhung shafts excepting as a telescopic shaft may be employed. Fine cleaning may be effected with the gas entering at the center and leaving at the periphery or vice versa. The Theisen disintegrator employs the former method and the Schwartz-Bayer type the latter. The Theisen design also incorporates a fan in the disintegrator construction, the fan blades being located outside the circle of the disintegrator proper. This fan element is used to overcome the loss of pressure in the machine and to create a further pressure for delivery to the point of use. In the case of the Theisen disintegrator the water is fed into a perforated revolving drum which surrounds the shaft, the water issuing from the perforations and striking the rotating bars of the disintegrator.

Power and Water Consumption in Disintegrators

Variations in the details of design of the disintegrator have been made as a means of reducing the power consumption where extremely fine cleaning was not required. These include reduction in the number of circles of rotating and stationary elements from six to four, and also the elimination of the stationary elements. These are practicable methods of producing the desired result. Recent development, however, is in the direction of increasing the gas flow through the disintegrator without varying the amount of water fed to the machine, as a means of reducing both the power and water consumption of the operation. The water supply is maintained practically constant and the use of power varies almost exactly as the water. The demand for power by the disintegrator proper is almost entirely independent of the amount of gas which passes through the machine, although there is some increase in the power required by the fan with higher rates of delivery of gas.

The change in method, therefore, consists merely in the operation of the disintegrator beyond its rated capacity. The loss in fineness of cleaning is comparatively slight and the disintegrator is capable of operation at a capacity of 60 per cent or more beyond that for which it is designed when the finest possible cleaning is desired. At this 60 per cent overload rating the degree of cleanness is well below that possible to obtain in secondary washers of the fan type. A statement of the circumstances of operation under various conditions of load is shown in the table below.

The figures here shown indicate the possibility of sufficiently fine cleaning for all uses excepting gas engines and coke underfiring with a very greatly lessened consumption of power as compared with that formerly considered necessary for disintegrator operation. It should also be noted that the kilowatt given for maximum output of gas compares with about 6.6 kw., where the fan system of cleaning is employed. the degree of cleanness in the latter case being .04 grains per cubic foot.

Mechanical wet cleaning by either the disintegrator or the fan method involves the provision of a water separator after the mechanical washer. In Germany this separator usually takes the form of a chamber provided at the bottom with a water seal and containing a system of inclined baffles against which entrained particles of moisture may strike. This results in the aggregation of finer particles into large drops and the elimination of water by running down the inclined surfaces of the baffles. These separators are either rectangular or circular in cross-section and for a disintegrator of 35,000 cu. ft. per minute will have a diameter of about 9 ft. and a height of 18 or 20 ft.

Disposal of Sludge

The wet washing method involves the disposal of the dirt removed from the gas as sludge and several variations in method of accomplishing this separation are practiced. At one plant a system of air pumps and tanks is employed, the sludge combined with the proper proportion of water being sucked into the tanks under vacuum and afterwards ejected through the delivery pipe by pressure. At another plant the water is clarified by treatment of milk of lime and subsequent subsidence. This lime is mixed with the gas washer effluent by means of an undershot water wheel which operates a system of small buckets, these buckets rotating on the same shaft which carries the water wheel and successively dipping into the lime solution and at the proper point in the circle of rotation ejecting it into the stream of gas washer water. The lime feed is thus maintained proportional to the amount of gas washer effluent. At this plant, where 175,000,000 cu. ft. of gas per day are cleaned, the consumption of lime is 11,000 lbs. per day. The clarification of the water is for all industrial purposes complete. The dust settles to the bottom of the settling basins of which two are provided in order to permit alternate cleaning. Subsequent removal is by means of a pump with disposition by means of freight cars to the dump. Other settling basin installations employ grab buckets for cleaning of the compartments of the system after subsidence of the dust and drainage of the water. Generally speaking, I would say that none of these systems are equal in convenience and overall cheapness of operation to the combination of the Dorr thickener and the vacuum filter as now used in America.

There is apparently no attempt to sinter or otherwise treat the dust from the washer for further metal-

Experimental Operation of Disintegrator with Varying Amounts of Water and Gas.

		Cooling tower water.			Disintegrator.			Temperature of Gas					
Duration of Test	Gas quantity cu. ft. per min.	Gals. per min.	Gals. per M cu. ft. gas	Dust content after cooling tower, grains cu. ft.	Water gals. per M cu. ft. gas	Dust after disintegrator grains cu. ft.	Water to tower and disintegrator Gals. per M cu. ft. gas	Tower Before deg. F.	Tower After deg. F.	After disintegrator deg. F.	Kw. per M cu. ft. gas per min.	Gals. water to disintegrator min.	Kw. Used. Disintegrator
Aug. 2–Aug. 21..	35,314	850	24.08	.35	7.54	.0012	31.62	...	About	About	11.74	266	415
Aug. 23–Aug. 30..	41,200	934	22.66	.29	6.37	.0014	29.03	240	68	68	9.81	262	404
Sept. 23–Sept. 24.	50,028	1,010	20.20	.36	4.03	.0022	24.23	to	to	to	7.22	209	361
Sept. 27–Oct. 5...	52,971	1,082	20.42	.33	4.22	.0038	24.64	356	72	72	6.85	224	363
Oct. 6–Oct. 11...	58,857	1,291	21.93	.31	3.81	.0044	25.74	...	......	......	5.85	224	344

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lurgical use. The dust is, generally speaking, low in iron content and in some cases contains considerable proportions of lead and zinc which are undesirable for further use. The sludge is therefore either stock piled with a view to possible future use, or it is put over the dump. In some cases it is used after two or three years in the stock pile for back filling of the coal mines in order to prevent subsidence of the surface.

Wet Cleaning by the Double Entry Fan

An alternative to the use of the disintegrator in mechanical wet cleaning is the use of the fan as designed and manufactured by Zschokke and Dinnendahl. The apparatus is in this case exactly what its name suggests, a double entry fan. Adaptation to gas washing is effected by the inclusion in the construction of a turbine wheel mounted on the shaft and located in each gas inlet. The outside of these wheels is open and a feed pipe enters the fan just below the shaft and discharges into the turbine wheel. The opening between the blades of the turbine is set at an angle to the axis of rotation so that the water is projected into the fan along with the stream of entering gas. As stated above the current requirement per 1000 ft. of gas per minute is about 6.6 kw. The water requirement is somewhat greater than that of the disintegrator and the limit of cleanness of the gas is .04 grains per cubic foot. At the most progressive plants the disintegrator is therefore preferred. The other elements in the wet washing system where the fan is employed are exactly the same as where the disintegrator is usd and consist of pre-cooler, fan, water eliminator and provisions for sludge disposal.

Bag Filters for Dry Cleaning

An alternative to the wet cleaning method and one which has been practiced on a very considerable scale in Germany for many years is the Halberger-Beth system of bag cleaning. This system, as the name indicates, was developed by the Halberger-Huette and was taken over and manufactured by Zschokke, who had also developed the fan system of wet cleaning. The unit of Halberger-Beth plant consists essentially of a rectangular chamber in which bags of cotton fabric are stretched on frames so as to form a complete mechanical filter for the gas. As usually constructed the bag filters are arranged in two rows, one on either side of the chamber with about 12 pairs of bags making up the unit. This arrangement is made in order to facilitate the periodical cleaning of the filters which is necessarily practiced. The capacity of one chamber is about 20,000 cu. ft. of gas per minute. The gas enters the chamber and is forced from the outside of the bags to the inside. Each bag has a separate outlet pipe into a common header for washed gas, the header being located above the cleaning chamber on a line with the long axle. The bottom of the chamber is divided into two bins, one under each row of bags, the intersection of the bin slopes being parallel to the long axis of the chamber. In each of these troughs is located a screw conveyor by means of which the dust is conveyed to a separate bin beneath.

The system necessarily includes a set of mechanical hammers, one for each bag and, a secondary system of piping through which a small percentage of purified gas is delivered to the inside of the bags and forced through the fabric in the reverse direction from the ordinary flow for the purposes of cleaning. This percentage of gas is about 6 to 10. The reversal of flow for periodical cleaning is automatically effected, so that each bag is cleaned and hammered in turn. The mechanical means for accomplishing this cleaning are beautifully worked out and are entirely automatic. A system of shafts mounted on either side of the cleaning chamber successively close the exit valve from the bag to the cleaned gas header, open the valve for reversed flow of purging gas and operate the hammer. After this cleaning has proceeded for a few seconds, the hammering ceases and the valves are again reversed. These mechanical features are thoroughly reliable and cause little trouble or expense. The general circumstances of operation, however, require very close observation and control. The temperature of the gas must be below 100 deg. C., this temperature being the upper limit to which the bags may be exposed without rapid deterioration. On the other hand the gas must be kept above the dew point which is usually about 50 deg. C., and the operation must be carried on between these limits. The long mains of large diameters which carry the gas to the central cleaning plant have a very considerable cooling effect, and at many plants it is possible during much of the year to cool to the proper temperature without special means. However, the system necessarily includes a system of tubes contained within a tower on the inlet side of the system. These tubes may be used to carry low pressure steam for heating the gas or cooling water for reducing its temperature. On the outlet side of the cleaning system an after-cooling tower, quite similar to those employed in wet washing, is usually located in order to reduce the temperature of the gas to a point at which moisture will not drop out in the pipe or at the burner.

The drop of pressure through the bag system is very considerable. As the plants are usually constructed, it amounts to 4 in. of water. The system always includes large fans which are placed on the outlet side of the cleaning system so as to take advantage of the cleanness of the gas. Avoidance of a vacuum within the system therefore requires a pressure from the furnace top which is sufficient to leave 4 in. of water at the filters or the operation of the filtering chamber under a vacuum. These chambers are provided with doors opposite each bag in order to facilitate the renewal of the filters and these doors must under conditions of vacuum be kept absolutely air tight in order to avoid mixtures of air and blast furnace gas. The installation in every case includes a complete set of pressure gauges for observation throughout the system registering within the fan room. The danger of a vacuum in the system may be obviated by the reduction in speed of fans, by decreasing the number in operation or by throttling the outlets. This procedure may be so conducted that a sufficient pressure will be created on the inlet side to force the gas through the filter and such a system of control seems absolutely necessary for safe operation. However, occasional operation with a vacuum in the system seems to be not unusual in some German plants.

The power requirement for the Halberger-Beth system is about 1.5 kw. per 1000 cu. ft. of gas per minute for the fans and 1.2 kw. for all other purposes, the total being 2.7 kw. per 1000 cu. ft. of gas per minute.

The fineness of cleaning with the Halberger-Beth system is very good. It is probable that the average of results produced are somewhat better with this system than with the disintegrator, although inspection of operating records show that this is not necessarily the case. The cost of the Halberger-Beth system is higher than with the disintegrator and the amount and skill of supervision required is also greater. The system has been in use for many years and is well regarded.

Electrical Precipitation

The newest method of gas purification and one which is exciting a very considerable interest on the part of all German iron and steel men is the electrical precipitation system. This is based on the American patents of Cottrell and on the contemporaneous work of Mueller. At the present time it is being pushed by two separate organizations, the Siemens-Schuckert Company and the Elga Electric Gas Cleaning Company. The former company is well known as one of the largest and most successful German manufacturers of electrical equipment. The Elga Company was formed by a combination of Zschokke and Dillingen, at which works an experimental plant for the development of the electrical system was built several years ago. Much of the development of the Siemens-Schuckert system was obtained at Dortmunder Union where an experimental plant was constructed in 1923. At the present time the largest electrical gas cleaning plant in operation is that at Witkowitz in Czecho-Slovakia which was installed by Elga. This plant has a capacity of 35,000 cu. ft. of gas per minute and an extension of the same size is nearing completion. The largest plant under construction is that now being built by Elga for A. G. Mannesman. This plant is to have a capacity of 162,000 cu. ft. of gas per minute. Two other smaller plants are also under construction by Elga. Siemens-Schuckert is constructing a plant of 118,000 cu. ft. capacity per minute for the new Krupp works at Berge-Borbeck, together with four smaller plants.

The underlying principles of electrical precipitation are well understood in America, and the system was several years ago applied at Dunbar, Pa., its most recent application having been at the plant of the Colorado Fuel & Iron Company. Neither Siemens-Schuckert nor Elga have made any radical or revolutionary change in the original principles as developed by Cottrell and Mueller. Much careful study of details both with respect to the electrical conditions and to the difficulties resulting from the composition of the gas has been done. This study has not resulted in complete agreement between the two companies as to the conditions necessary to fulfill, nor as to the preferable means to be employed. Both companies require a temperature in the gas below 100 deg. This is necessary in order to make certain that all vapors of silica and other slag making materials formed in the furnace are condensed. Elga also embodies in its system a requirement as to relative humidity of the gas on account of the greater electrical resistivity of gas as it approaches the point of saturation. The Siemens-Schuckert idea is that the separation may be effected independently of the degree of saturation of the gas. Elga has also embodied in its plant at Witkowitz the idea of cleaning of the system by means of purge gas which has been described in referring to the Halberger-Beth system. An inclination toward this procedure probably arises from the previous experience of the company with that system. The Elga purifier, therefore, stops the flow of uncleaned gas in each section of the precipitator, in turn, shuts off the current and reverses the direction of flow of gas, using previously purified gas as means of cleaning. Siemens-Schuckert propose a continuous use of the compartments with no reversal of flow. Both systems, however, include mechanical hammers automatically operated as means of cleaning. It therefore appears that the Siemens-Schuckert system if equally successful in effecting purification is preferable to the Elga with respect to the use of purified gas for cleaning and with respect to the necessity of maintaining a definite condition of relative humidity. These differences will result in a much simpler and cheaper operation in the case of the Siemens-Schuckert. A complete knowledge as to the correctness of these conflicting ideas is as yet lacking.

Variations in Electrical Devices

It is interesting to note the differences in construction whereby Siemens-Schuckert propose to eliminate the complications just referred to as applying to the Elga. The latter company employs a tubular construction, the cleaning unit being a vertical pipe about 6 in. in diameter and containing a single positive electrode running through its center. The voltage of the Elga is 40,000.

On the other hand the Siemens-Schuckert employ a rectangular compartment in which the positive electrode consists of a section of wire mesh extending practically across the compartment. The electrode surface in proportion to the total volume within the compartment is therefore greater than is the case with the Elga. The proposed voltage for the Siemens-Schuckert installation is 60,000. Furthermore, the Siemens-Schuckert system contemplates two passes for the gas within the electric field, entry being at the top of a primary compartment which is connected to a secondary compartment at the bottom, the gas traveling downward in the primary and upward in the secondary, and being exposed to the electrical action in both compartments. The total travel of the gas within the electric field is about 30 ft. in the Siemens-Schuckert system and about 11 ft. in the Elga. The proposed velocity of the gas in the two systems is not sufficiently different to result in an equal time exposure of the gas, a maximum velocity of about 10 ft. per second being contemplated in both cases.

The present plant at Witkowitz consists essentially of a long rectangular chamber in shape exactly similar to that used for the Halberger-Beth. The individual units of the electrical precipitators are disposed in this chamber in two rows. Each unit is composed of seven vertical pipes forming a cluster. Each cluster is contained within a rectangular compartment built of plate work. Raw gas conduits are provided on either side of the chamber near the bottom. The gas enters from these conduits and rises in the pipes, proceeding thence to pure gas conduits parallel to and located above the raw gas conduits. Between each unit and the cleaned gas conduit is a valve provided with means for automatic opening and closing. Cleaned gas is also piped along on both sides of the system and distributed by means of a separate pipe entering each cleaning compartment. Each unit is

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also provided with automatic mechanical hammers and an automatic switch for shutting off the electrical current. The cleaning operation is carried on automatically, each compartment being treated in turn. The current is switched off, the valves reversed so that the normal flow ceases and pure gas enters the compartment in the reverse direction, while at the same time the pipe assembly is pounded by the mechanical hammers. The percentage of gas used for purification runs from 10 to 12.

Pre-cooling and Humidifying

Auxiliary features of the installation include a precooler for the gas which is similar to an ordinary small spray tower. In this tower the purpose is to cool and humidify the gas without precipitation of moisture. The means of water distribution are not sufficiently good to make this attempt entirely successful. About 60 per cent of the water sprayed is absorbed into the gas and the other 40 per cent is withdrawn at the bottom of the tower. The gas is cooled to about 70 deg. C. in the pre-cooler. On entering it contains 30 to 35 grains water vapor per cubic foot. About 9 grains more water is added in the tower. This amount of water is not considered sufficient, and at the present time a small portable boiler is employed to make additional steam which is discharged into the gas main ahead of the purifier. Six grains more per cubic foot are added by the boiler. With the electric system of purification it is of the utmost importance to prevent the dropping of the temperature of the gas below the dew point. In the Halberger-Beth system this results in deposition of mud upon the filters, a condition which would become serious if it persisted for any length of time but which momentarily causes no damage. The condensation of water vapor upon the insulators of the electric installation will cause a short circuiting which puts the entire system out of operation. The likelihood of such an event is increased by the necessity of operating with the gas 85 per cent to 90 per cent saturated with water vapor. In order to avoid the possibility of condensation, a heater is provided for the reheating of the purge gas subsequently used in purification. This heater resembles a vertical tubular boiler and is supplied with fuel in the shape of clean blast furnace gas, the daily consumption being 175,000 cu. ft. The observed rate of use of current for operation at the rate of 27,000 cu. ft. of gas per minute was 7 kw. The drop in pressure through the cleaners is 1.6 in. The purified gas is taken directly in a long main to the stoves, the gas engines on the plant being still supplied with gas cleaned by a disintegrator. A very considerable amount of water drops out in this pipe, but in view of the fact that it is practically clean, no inconvenience is caused. The walls of the combustion chamber were perfectly clean and the gas flame showed the blue color which characterizes perfectly clean gas, with none of the pink tinge which results from the presence of impurities. This difference in color of flame is employed in the purifying plant as a means of control. The degree of cleanness is .01 grains of dust per cubic foot.

The new construction at Witkowitz varies from the plant at present in operation only with respect to the arrangement of the tubes in each section. The new plant proposes a section composed of 20 tubes instead of seven. In other respects the construction is practically the same.

No large plant of Siemens-Schuckert type is as yet in operation. The company has, however, given a positive guarantee to bring the gas down to .004 grains per cubic foot and operating experience based on the performance of this plant will be available within a few months.

New Centrifugal Method

In addition to the interest at present displayed in electrical precipitation there is also a considerable activity in the development of methods of dry separation of dust prior to wet washing. The most promising of these attempts appears to be in the apparatus now under construction in large German works which proposes centrifugal separation in a plurality of parallel horizontal pipes about 18 in. in diameter within which the gas is given a whirling motion by means of stationary screws. These pipes open on the lower side into a chamber without inlet or outlet excepting for dust removal, the gas being carried through the chamber within the pipes. This installation will shortly be in operation.

The average cost of cleaning by any of these systems varies in accordance with local circumstances, including the cost of labor, of water and of power. Available figures indicate that the cost with the wet method averages about $.00177 per 1000 cu. ft. of gas per minute. With the Halberger-Beth system the average cost is probably about $.00283 per 1000 cu. ft., although in one case a figure as low as $.00169 was taken from the company's records. The cost at Witkowitz was stated to be $.00146 per 1000 cu. ft. This cost would be increased to about $.0021 by reducing the output sufficiently to permit the production of engine gas. These figures will probably be increased by about 30 per cent for operation in America under the same conditions.

Costs of plant are difficult to compare on account of other variations in the construction aside from the gas cleaning system itself. The cost of the Halberger-Beth system is probably 40 per cent greater than that of wet washing with the disintegrator. The cost of the electrical system will be somewhat less than that of the Halberger-Beth on account of the greater amount of gas handled per unit.

Application of Gas Washing in America

Interest in gas washing in the United States is very properly first directed to its economic aspect and second to its means of application. The question in the minds of responsible Americans is, "Will fine cleaning of blast furnace gas pay?" The answer is most decidedly in the affirmative. It must, however, be understood that the expectation of profit through gas washing must be based on the fulfillment of all the conditions of economical use. Of these fine cleaning is the first. It must, however, be emphasized that the fine cleaning of gas is part of a system of heat economy which includes skilful allocation of the gas in accordance with its nature and the character of the uses to which it may be possibly applied. The system also involves adequate furnace of good design, the proper means of combustion and close control. Blast furnace gas has a nominal heat value of approximately $1.90 per ton of pig iron, based on an average price of coal of $1.90 including cost of firing. After cleaning the freedom from nuisance, ease of transportation and control and avoidance of expense for gasification or firing, make it worth considerably more than its nominal heating value plus the cost of cleaning. In its uncleaned condition it is worth very considerably less than this amount.

Practically all of the recent American advances in metallurgy have been closely connected with the better preparation of raw materials and of fuel. Our ores are now closely graded, our coking coals are selected in accordance with their character and brought from great distances in order to produce a mixture exactly suitable for use. Our steel making processes are now based on a substantially uniform character of pig iron, the specifications for which correspond exactly to metallurgical requirements. The more complex rolling and fabricating processes are entirely dependent upon a correct quality of steel. Of all the important materials which enter into steel production on a large scale, blast furnace gas has been most neglected with respect to preparation and intelligent use. Fine washing of this gas may be expected to produce results as profoundly important and as far reaching in proportion to the value of the materials involved as has the grading of ores and the selection and classification of coals. These two latter processes of selection and preparation have made possible the results commonly attained by the by-product coke oven as now constructed and in the modern blast furnace. The present tendency is to increase the care exercised in the preparation of ore and of coal and no one for a moment would consider the abandonment of any of the precautions now taken with respect to the preparation of these materials. Once the corresponding preparation has been practiced with respect to blast furnace gas and the benefits of its use in properly designed apparatus have been realized, there will be an equally strong realization of the folly of returning to the methods of preparation generally heretofore practiced in America. The reduction in operating expense possible through the proper application of washed blast furnace gas remains the most important single unrealized means of reducing the cost of American steel.

Comparison of Methods for American Practice

With regard to the technical means to be employed in the proper preparation of gas, it is probable that the broad experience which will be gained in the near future in the electrical precipitation in Germany will lead to a considerable application of this method in the United States. It seems probable, however, that it will be necessary for this development to demonstrate that cleaning may be carried out in a straight away process without the use of 10 per cent of the gas for purification of the system and without the complications resulting from the necessity of extremely close control of temperature and humidity as now practiced in the Elga system. The development of gas cleaning under a system which proposes freedom from these complications has as yet been on a scale that is little more than experimental. The financial and technical strength of the developing company and the positive guarantees which they have given with regard to the plants now under construction indicate a strong probability of successful operation of electrical precipitation plants under circumstances which will be interesting in America.

In the meantime, wet cleaning by the disintegrator method remains the simplest, cheapest and most flexible of the thoroughly tried systems developed by Continental experience. Recent developments in Germany make possible a substantial reduction in the power and water consumption of the disintegrator when cleaning for many purposes and a still further reduction in power may be made by the separation of the fan from the disintegrator proper and in many cases by its entire elimination with propulsion of gas by the blowing engines. Recent American developments in dry cleaning by the Vortex principle will make possible the reduction in cost of disposal of the sludge attendant upon wet washing. This cost is practically proportional to the amount of dust removed in the wet system rather than on the amount of gas handled. The preliminary removal of a large percentage of the dust by dry methods will not only effect a substantial reduction in the cost of wet washing but will enable a classification of flue dust into dry and wet which can be made to correspond to the degree of fineness above which sintering of the dust is possible by present methods. Wet cleaning by the use of the disintegrator may therefore be expected to have a continued use irrespective of the development of the electric precipitator. It is also probable that the increasing American interest in fine gas cleaning will result in modifications of present plant and practice which will still further reduce the cost. As practiced in Germany, however, the science and art of gas cleaning has been sufficiently developed to form an entirely sound basis for American installations and is therefore possible for the American industry to proceed rapidly to a realization of the important heat economies possible through the application of washed gas as they have been described in this paper.

Program of Papers, American Iron and Steel Institute

New York, Friday, May 25, 1928

"Basic Open-Hearth Steel Practice," Dr. G. B. Waterhouse, professor of metallurgy, Massachusetts Institute of Technology, and consulting engineer and metallurgist, Cambridge, Mass.

"The Effect of Coal Segregation, Mixing and Heating upon the Quality of Metallurgical Coke," F. F. Marquard, assistant general superintendent, Carnegie Steel Company, Clairton, Pa.

"The Manufacture of Alloy Steels," E. C. Smith, Central Alloy Steel Corporation, Massillon, Ohio.

"The First Iron Works in America—1645," Howard Corning, Baker Library, Harvard University, Cambridge, Mass.

"Waste Heat Boilers," R. H. Stevens, chief engineer, Cambria Plant, Bethlehem Steel Corporation, Johnstown, Pa.

"The Trend in Ingot Mould Design," R. H. Watson, assistant general superintendent, Homestead Works, Carnegie Steel Company, Munhall, Pa.

"A Modern Steel Works Power and Blowing Plant," Wilfred Sykes, assistant general manager, Inland Steel Company, Chicago, Ill.

Carbons to Meet Tensile Specifications

The Table Here Given Provides for the Ready Application of Open-Hearth Melts at the Mill on the Ladle Test Figures Against the Usual Run of Structural Requirements

By J. R. MILLER

THE problem of applying open-hearth steel in arranging to fill orders under structural specifications involves a judgment of the quality of the material based on ladle test figures. The prob'em is the same in scheduling steel on the open-hearth as it is in applying heats, already made, to rollings in progress.

Inasmuch as steel for structural purposes is in general not over .60 manganese and not over .04 phosphorus, carbon content is the factor that governs. If melts are used that are over Phos. .04 due allowance must be made for the effect of that element upon the physical properties of the section.*

Similarly if melts are applied that contain silicon that fact must be known and duly taken into account. Certain special structural specifications contemplate the addition of silicon for high tensile material, but these are out of the usual ranges

Since carbon is the one chemical factor which may be varied more or less at will without introducing an undue uncertainty of result, we depend upon it to fix the grade of the material. Therefore it is necessary to know how to judge what effect upon the physical characteristics of the various sections will result from a given carbon content.

It is quite well known that the carbon content required to meet given tensile specifications varies greatly with the heat treatment and working to which the steel is subjected; and so varies with the size and section.

The practice of different mills varies somewhat and it is not always safe to use the standards of one practice in a place where a different practice prevails, however good judgment can be used and proper allowances made for variations in methods and specific conditions.

The table given below has been the result of a long series of years of practice in a mill rolling a large variety of shapes and bars and was used as a standard in applying melts on ladle analysis. It follows the general run of specification limits as they appear on the order sheets and tabulates definite ranges of size and section so that it is handy to use.

It must be noted that the table is arranged with some little margin of safety making al'owance for the usual variations met with in mill practice.

	SPECIFICATION LIMITS FOR TENSILE STRENGTH†													
Sections Hot Rolled Bars and Shapes	45–55 46–54 46–56	48–56 48–58	50–58 50–60 50–62	52–60 52–62	54–62 54–64 54–65	53–66 55–65 56–64 56–66 56–68	55–70	57–65 58–66 58–68 59–67	60–68 60–70	61–71 62–72 62–70 63–71	65–75 66–74	70 min. 70–80 70–85	75 min. 75–90	80 min.
A. ‖	07 — 15	13 — 18	15 — 20	17 — 22	19 — 24	20 — 26	20 — 30	23 — 28	25 — 30	26 — 31	30 — 36	36 — 44	42 — 49‡	47 — 55
B. ‖	07 — 12	12 — 17	13 — 18	15 — 20	17 — 22	18 — 24	18 — 28	21 — 26	23 — 28	25 — 29	28 — 33	33 — 40	39 — 46	44 — 52
C. ‖	07 — 11	10 — 15§	11 — 16	13 — 18	15 — 20	16 — 22	16 — 26	19 — 24	21 — 26	23 — 27	26 — 31	30 — 37	35 — 42	40 — 48
D. ‖	07 — 11	07 — 11	07 — 11	10 — 14	12 — 16	13 — 18	13 — 21	15 — 20	17 — 21	19 — 23	22 — 26	25 — 32	29 — 36	33 — 40

*For Basic or Acid heats over .04 phos.
Phos. .041–.049 apply as if .02 higher in carbon.
Phos. .050–.059 apply as if .04 higher in carbon.
Phos. .060–.069 apply as if .06 higher in carbon.
Phos. .070–.080 apply as if .08 higher in carbon.
Higher phos. apply as if Bessemer.

†In 1,000 lbs., 45–55 = 45,000 to 55,000 T. S.

‡For bars over 6 in. diameter use C. .45–.50.

§For rivet steel use C. .07–.11.

‖A.—Beams: 15 in. x 90 lb. and heavier.
Flats, angles, tees, zees, etc.: Over 1 in. thick.
Rounds, squares, etc.: Over 1¾ lb.

B.—Beams: 24 in. x over 80 lb., 20 in. x over 65 lb., 18 in. x over 55 lb., 15 in. x over 50 lb., 12 in. x over 40 lb., 10 in. x over 30 lb., 9 in. x over 30 lb.
Channels: 15 in. x over 40 lb., 13 in. x over 40 lb., 12 in. x over 30 lb., 10 in. x over 20 lb.
Flats, angles, tees, zees, etc.: ½ in. to 1 in. thick, over ⅞ in. wide.
Rounds, squares, etc: 1 in. to 1¾ in.

C.—Beams: 24 in. x 80 lb. only, 20 in. x 65 lb. only, 18 in. x 55 lb. only,, 15 in. x 42 lb. to 50 lb., 12 in. x 31½ lb. to 40 lb., 9 in. x 21 lb. to 30 lb., 8 in., 7 in., 6 in. and 5 in. all weights; 4 in. x over 7½ lb., 3 in. x over 5½ lb.
Channels: 15 in. x 33 lb. to 40 lb., 13 in. x 31½ lb. to 40 lb., 12 in. x 20½ lb. to 30 lb., 10 in. x 15 lb. to 20 lb., 9 in., 8 in., 7 in., 6 in. and 5 in. all weights; 4 in. x over 5¼ lb., 3 in. x over 4 lb., also all sections ship channels.
Flats, angles, tees, zees, etc.: ¼ in. to 7/16 in. thick, over ⅞ in. wide.
Rounds, squares, etc.: 7/16 in. to 15/16 in.

D.—Beams: 4 in. x 7½ lb. only, 3 in. x 5½ lb. only.
Channels: 4 in. x 5½ lb. only, 3 in. x 4 lb. only.
Flats, angles, tees, zees, etc.: Under ¼ in. thick, all flats ⅞ in. wide and under.
Rounds, squares, etc.: Under 7/16 in.

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British Patents of Seamless Steel Tubing

This List Has Been Compiled as an Aid to Those Making a Study of Manufacturing Processes, and to the Producer of Steel in the Tubular Form

By VICTOR S. POLANSKY*

THE search for British patents is expedited by the Classified Abridgments issued by the patent office. The first series covers the years 1617-1883. The new series, with illustrations, runs from 1877 to date, the latest section issued covering patents through 1920. Class 83, part 4 is devoted to seamless steel tubing.

Prior to 1916, British patents were renumbered each year, and the date is thus necessary for identification.

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Briede, Otto. Improvements in the Method of and in Mills for Rolling Seamless Tubes. (8,477 of 1913.)

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Complete patent not available. Abridgement only.

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Mannesmann, Max. Device for Turning the Blank in Step by Step Rolling Mills. (23,076 of 1903.)

Mannesmann, Max. Improved Feed Apparatus for Rolling Mills. (28,696 of 1902.)

Mannesmann, Max. Improved Method of and Apparatus for Forming, Rolling, and Finishing Metals. (4,050 of 1891.)

Mannesmann, Max. Improved Spring Devices in Connection With the Mandrels Carrying the Work Pieces in Step by Step Rolling Mills with Reciprocating Roll Frames. (14,658 of 1904.)

(To be continued)

Sales and Engineering Staff of Gears and Forgings Inc.

Front row, left to right: W. C. Bates, district sales manager, Pittsburgh territory; R. B. Tripp, sales manager, forgings; F. W. Sinram, president; C. F. Goedke, district sales manager, Chicago territory; L. G. Hewins, sales manager, gears; H. B. Newel, chief engineer; F. J. Niedermiller, district sales manager, Detroit territory; S. C. Dalbey, secretary and treasurer.

Location, Number, Capacity and Range of Pipe Mills in United States by Companies*

	BUTTWELDED			LAPWELDED			SEAMLESS			Annual capacity, tons			
Company	No. furnaces	Diameters produced, inches min.	max.	No. furnaces	Diameters produced, inches min.	max.	No. mills	Diameters produced, inches min.	max.	Black	Galvanized	Seamless	Boiler tubes
Allegheny Steel Co., Brackenridge, Pa.	..	..	...	2	2	6	..	...	....	....	......	......	12,000
Babcock & Wilcox Tube Co., Beaver Falls, Pa.	..	..	...	..	...	....	2	2	6	....	......	60,000	......
Bethlehem Steel Co.,													
Coatesville, Pa.	..	..	...	6	1½	6	..	...	....	....	......	......	16,000
Sparrows Point, Md.	2	¼	3	2	...	....	..	...	....	115 000	30,000	......	......
Byers, A. M., Co., Pittsburgh	1	¼	1½	2	1¼	12½	..	...	....	65,000	25,000	......	......
Central Tube Co., Economy Pa.	4	¼	3	1	4	8	..	...	....	150,000	100,000	......	......
Cohoes Rolling Mill Co., Cohoes, N. Y.	1	¼	2	..	...	....	..	...	....	18,000	12,000	......	......
Delaware Seamless Tube Co., Auburn, Pa.	..	..	...	..	...	....	2	¼	3½	....	......	10,000	......
Detroit Seamless Steel Tubes Co., Springwells, Mich.	..	..	...	..	...	....	1	½	6	....	......	30,000	......
Gary Tube Co., Gary, Ind.	5	⅜	3	4	2	20	1	4½	13	318,000	60,000	60,000	......
Globe Steel Tubes Co., Milwaukee	..	..	...	..	...	....	1	½	5¼	....	......	36,000	......
Jones & Laughlin Steel Corp., Woodlawn, Pa.	4	⅛	3	3	2	16	1	2	6	300,000	40,000	30,000	......
Mark, Clayton & Co., Chicago	2	¼	3	..	...	....	..	...	....	92,000	......	......	......
Monongahela Tube Co., Wilson, Pa.	..	..	...	2	1½	6	..	...	....	13,000	......	......	10,000
National Tube Co.,													
Benwood, W. Va.	5	⅛	3	2	2	6	..	...	....	128,000	29,000	......	......
Lorain, Ohio	6	⅛	3	7	2	20	..	...	....	432,000	78,000	......	......
McKeesport, Pa.	6	⅛	3	11	2	24	1	...	....	350,000	67,000	......	28,000
Ellwood City, Pa.	..	..	...	..	...	....	7	1¼	8¼	....	......	190,500	......
Pittsburgh, (Continental Works)	2	¼	2	1	2	8	..	...	....	92,000	......	......	......
Pittsburgh (Pennsylvania Works)	..	..	...	6	2	12	..	...	....	300,000	......	......	......
Ohio Seamless Tube Co., Shelby, Ohio	..	..	...	..	...	....	2	3	6	....	......	35,500	......
Pittsburgh Steel Products Co.,													
Allenport, Pa.	..	..	...	..	...	....	3	3	6	....	......	60,000	......
Monessen, Pa.	..	..	...	..	...	....	4	½	12	....	......	140,000	......
Reading Iron Co., Reading, Pa.	3	⅛	1½	5	1¼	20	..	...	....	155,000	25,000	......	20 000
Republic Iron & Steel Co., Youngstown, Ohio	4	⅛	3	3	2	16	..	...	....	270,000	43,000	......	......
South Chester Tube Co., Chester, Pa.	..	..	...	1	2	12	..	...	....	65,000	......	......	......
Spang Chalfant & Co., Inc., Etna, Pa.	3	⅛	3	4	2	24	..	...	....	200,000	24 000	......	7,000
Standard Seamless Tube Co., Ambridge, Pa.	..	..	...	..	...	....	1	1	4	....	......	60,000	......
Timken Roller Bearing Co., Canton, Ohio	..	..	...	..	...	....	1	⅝	6½	....	......	35,000	......
Tyler Tube & Pipe Co., Washington, Pa.	..	..	...	4	1½	6	..	...	....	30,000	......	......	15,000
†Weldless Tube Co., Wooster, Ohio	..	..	...	..	...	....	1	½	3¼	....	......	18,000	......
Wheeling Steel Corp.,													
Steubenville, Ohio	2	⅛	3	2	2	12½	..	...	....	110,000	50,000	......	......
Benwood, W. Va.	3	⅜	3	2	2	12½	..	...	....	125,000	25,000	......	......
Youngstown Sheet & Tube Co.,													
Campbell, Ohio	6	⅛	3	5	2	20	2	2⅜	13⅜	600,000	110,000	144,000	......
Evanston, Ill.	2	¼	3	..	...	....	..	...	....	72,000	30,000	......	......
Indiana Harbor, Ind.	2	⅛	3	3	2	20	..	...	....	240 000	30,000	......	......
Zanesville, Ohio	2	¼	3	2	2	16	..	...	....	120,000	27,000	......	......
TOTAL	65			80			30			4,360,000	805,000	909,000	123,000

*From Daily Metal Trade. †Idle.

Study of Elements in Coal Carbonization*

Their Distribution in the Substances Formed by the Distillation Process Is Outlined in Tabular Form and Discussed—Methods of Determination

By FRED M. REITER†

ONE of the interesting studies of the carbonization process is the distribution of elements throughout the distillation of the coal. The tracing of these elements and componds through the products gives results that are almost mathematical in calculating the analysis, quantity, etc., from a primary distribution of the elements.

TABLE I

Distribution of Elements

PRODUCT

Element	Per cent of coal	State	Name	Per cent of coal	Sub-Total per cent of coal	Total per cent of coal
Moisture.	3.31	Liquid	Ammonia liquor .		......	3.310
Ash	7.21	Solid	Ash	......	......	7.210
Carbon ..	76.00	Solid	Coke ...	61.611	61.711	61.711
			Retort carbon.	0.100		
		Liquid	Tar	......	......	4.687
		Gas	CO_2	0.284	8.548	9.602
			CO	1.352		
			CH_4	5.601		
			C_2H_4(Ill.)	1.311		
		Vapor	C_6H_6	1.016	1.054	
			C_2N_2	0.036		
			CS_2	0.002		
Hydrogen	4.78	Solid	Coke	......	0.715	0.715
		Liquid	Ammonia liquor .	0.388		
			Tar	0.327		
		Gas	Hydrogen	1.366	3.451	3.596
			Methane .	1.867		
			C_2H_4(Ill.)	0.218		
		Vapor	Benzol ..	0.086	0.145	
			NH_3	0.040		
			H_2S	0.019		
Oxygen .	6.82	Liquid	Tar	0.435	3.543	3.543
			Ammonia liquor .	3.107		
		Gas	CO_2	0.758	2.560	3.277
			CO	1.802		
		Vapor	Vapors ..	0.717	0.717	
Nitrogen.	0.88	Solid	Coke	......	......	0.270
		Gas	Nitrogen .	0.385	0.385	0.610
		Vapor	NH_3	0.183	0.225	
			C_2N_2	0.042		
Sulphur .	1.00	Solid	Coke	......	......	0.683
		Vapor	H_2S	0.305	0.317	0.317
			CS_2	0.011		
Totals .	100.00					100.000

Several decades ago Euchene made up a distribution sheet of the elements throughout the coking process. Based upon his method, a tabulation has been prepared for Pittsburgh coal, of the following analysis:

PROXIMATE	Per cent	ULTIMATE	Per cent
Moisture	3.31	Moisture	3.31
Volatile matter	35.42	Carbon	76.00
Fixed carbon	56.69	Hydrogen	4.78
Ash	7.89	Oxygen	6.82
		Nitrogen	0.88
	100.00*	Sulphur	1.00
*Dry.		Ash	7.21*
			100.00

*Ash is sulphur free.

This tabulation gives the elements found in the various compounds formed by the carbonization of the coal, the state of these compounds and the percentages by weight, of the original coal.

Our study is now based upon Table 1.

The character of the products that have been obtained from this coal would be readily obtainable from the grouping shown, as well as the quantity of each that would be got per ton of coal.

TABLE II

Product	Constituent	Per cent of coal	Total percentage	Pounds per net ton coal
Solid	Carbon	61.711		
	Hydrogen ...	0.469		
	Nitrogen	0.270		
	Sulphur	0.683		
	Ash	7.210	70.343	1,406.86
Liquid	Moisture	3.310		
	Carbon	4.687		
	Hydrogen ...	0.715		
	Oxygen	3.543	12.255	245.10
Gas	Carbon	8.548		
	Hydrogen ...	3.451		
	Oxygen	2.560		
	Nitrogen	0.385	14.944	298.88
Condensible or soluble vapors	Carbon	1.054		
	Hydrogen ...	0.145		
	Oxygen	0.717		
	Nitrogen	0.225		
	Sulphur	0.317	2.448	49.16
Total Products			100.000	2,000.00

By regrouping the elements given in the original tabulation, the yields of the various products and their analyses can readily be derived, Table III.

A recalculation of the data on the gas production, on a volumetric basis as found commercially is probably more valuable than gas analyses by weight. Based upon the derived analysis by weight, the volumetric analysis is determined in Table IV.

From the distribution given, there is no means of calculating the proximate constituents of the tar; namely, free carbon, various fractions, etc.

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*Gas Age-Record.

†Dayton Power and Light Company, Dayton, Ohio.

TABLE III

Product	Constituent	Per cent of coal	Analysis per cent of product	Yield, lb. per net ton
Coke	Ash	7.210	10.24	144.20
	Carbon	61.711	87.76	1,234.22
	Hydrogen	.469	.66	9.38
	Sulphur	.683	.96	13.66
	Nitrogen	.270	.38	5.40
	Total	70.343	100.00	1,406.86
Gas	CO_2	1.042	6.66	20.84
	CO	3.154	20.14	63.08
	Methane	7.468	47.69	149.36
	Illuminants	1.529	9.76	30.58
	Nitrogen	.385	2.46	7.70
	Hydrogen	1.366	8.72	27.32
	Oxygen, etc.	.717	4.57	14.34
	Total	15.661	100.00	313.22
NH_3	Hydrogen	.040	17.9	0.80
	Nitrogen	.183	82.1	3.66
	Total	.223	100.0	4.46
Tar	Carbon	4.687	86.0	93.74
	Hydrogen	.327	6.0	6.54
	Oxygen	.436	8.0	8.72
	Total	5.450	100.0	109.00
Liquor	Hygroscopic moisture	3.310	48.70	66.20
	Oxygen	3.107	45.60	62.14
	Hydrogen	.388	5.70	7.76
	Total	6.805	100.00	136.10
Light oil	All as C_6H_6	1.102	100.00	22.04
Cyanogen	C_2N_2	.078	100.00	1.56
Carbon bisulphide	CS_2	.013	100.00	.26
Hydrogen sulphide	H_2S	0.325	100.00	6.50

TABLE IV

Gas	Analysis by weight, per cent of product	Cu. ft. per lb. gas	Product of these	Analysis by volume, per cent
CO_2	6.66	8.593	52.23	1.60
CO	20.14	13.503	276.89	8.37
CH_4	47.96	23.626	1,116.96	33.73
Ill.	9.76	13.500	131.80	3.98
N_2	2.46	13.460	33.11	1.00
H_2	8.72	188.62	1,644.77	49.69
O_2	4.57	11.816	54.00	1.63
	100.00	....	3,309.76	100.00

This also holds true for the light oil components. benzol, toluol, etc.

From the original analysis of the coal, which showed a moisture content of 3.31 per cent, we can separate the combined moisture from the hygroscopic. The hygroscopic or adherent moisture is 3.31 per cent, while that formed by the reactions that take place in the ovens is the difference from the total liquor produced, or 3.495 per cent of the coal.

Following will be found a resume of the yields of the products, Table V.

TABLE V

Product	Yield, lb. per net ton	Per cent of coal
Coke	1,406.86	70.343
Gas	313.22	15.661
NH_3 gas	4.46	.223
Liquor	136.10	6.805
Tar	109.00	5.450
Light oil	22.04	1.102
Other vapors	8.32	.416
Total	2,000.00	100.000

Converting these yields into more popular terms would give:

Gas—0.38 specific gravity or 34.2 cu. ft. per lb. for 313.22 lb. gives a production of 10,712 cu. ft. per net ton.

Liquor—At 8.3 lb. per gal., yield is 136.10/8.3 or 16.4 gal. per net ton coal.

Tar—At 1.156 specific gravity, gives 9.6 lb. per gal., which for 109 lb. gives a yield of 11.4 gal. per net ton.

Light oil—At 0.86 specific gravity, or 7.1 lb. per gal. for 22.04 lb. gives a yield of 3.1 gal. per net ton coal.

Hydrogen sulphide—For yield of 6.50 lb. per net ton, corresponding to 10,712 cu. ft., generation of hydrogen sulphide would be 0.6 lb. per 1,000 cu. ft. gas, or 4.2 gr. per cu. ft.

The coke, ammonia gas, cyanogen, carbon disulphide and possibly other minor products are probably expressed in the units given, pounds per net ton of coal.

It might be well here to discuss somewhat the derivation of the yields and analysis of these products. These have been entirely obtained from the original tabulation of the "Distribution of Elements." The various elements or compounds have been regrouped under each product, followed by the per cent of coal of each constituent, as found on this "Distribution." This percentage multiplied by 2,000 lb., the weight of one net ton, gives directly the yield per net ton.

For example, under the product, "Coke," the per cent of coal of the total coke is obtained by summing the per cents of the constituents, ash, carbon, hydrogen, sulphur and nitrogen, which gives a total percentage or yield of 70.343 per cent. Multiplied by 2000 gives an actual weight yield of 1,406.86 lb. per net ton.

In this manner the yields of all the products can be obtained in any arrangement desired.

The individual analysis of each product is obtained from the percentages of coal or actual yields. For our example of coke, dividing the percentages of each of the ash, carbon, etc., by the total, 70.343, the per cent of the product or analysis is obtained. The same is true of the yield per net ton. The per cent of ash in the coke would be 7,210 divided by 70.343, or 144.20 divided by 1,406.86, giving a result of 10.24 per cent.

This procedure is followed throughout the list.

A fairly large coke plant, using the above coal, based upon the average of a year's operation, on a 19 hour coking cycle, gave the results shown in the following data.

These results when checked with the above distribution of products show very interesting comparisons.

Actually determined yields of the various products are as follows:

TABLE VI

Product	Yield, lb. per net ton	Per cent of coal
Total coke	1,436.98	71.85
Gas	317.85	15.89
NH_3 gas	6.41	.32
Liquor	155.62	7.78
Tar	104.03	5.20
Light oil	23.04	1.15
	2,043.97	102.19

This tabulation is based upon the following commercial yields:

Furnace coke	1,311	lb.	per net ton coal
Domestic coke	64.2	lb.	per net ton coal
Coke dust	125.2	lb.	per net ton coal
Gas	10 848	cu. ft.	per net ton coal
Ammonium sulphate	25.4	lb.	per net ton coal
Tar	10.806	gal.	per net ton coal
Liquor	19	gal.	per net ton coal
Light oil	3.17	gal.	per net ton coal

The method calculation of yields in terms of pounds per net ton of coal for the various products, is as follows:

Coke—This is the sum of all classes of coke produced corrected for their respective moisture contents as follows:

Furnace coke	3.03 per cent total moisture
Domestic coke	10.21 per cent total moisture
Coke dust	14.41 per cent total moisture

Gas—10.848 cu. ft. per net ton saturated at 30 lb. mercury pressure and 60 deg. F., weighing 0.0293 lb. per cu. ft. (specific gravity, 0.389).

Ammonia gas—Based upon ammonia content of 25.25 per cent of produced ammonium sulphate. All ammonia products converted into the normal sulphate.

Weak liquor—Ammonia free water, including all condensate and water recovered as metered by the Venturi meter showing the ammonia liquor fed to the ammonia stills. This also includes any drainage in the trenches, re-evaporation in collecting mains of flushing liquor, washings, etc., which find their way into the hot drain tank, and thence to the stills. Any leakage of primary cooler tubes, etc., is also included.

Tar—10.806 gals. per net ton, moisture free, specific gravity 1.156, making 9.267 lb. per gal.

Light oil—3.17 gals. per net ton coal, specific gravity 0.875, making 7.287 per gal.

The above yields show greater summation of products than the weight of the original coal, which, of course, is not a true condition. The weight of the coal should exceed that of the total products, as there is unavoidable loss during operation, such as occur in charging and pushing operations, distillation, washing and scrubbing processes, etc.

A careful rechecking of the actual yields with correction for all possible outside factors, discovered the true yields to be as follows:

TABLE VII

Product	Yield, lb. per net ton	Per cent of coal
Total coke	1,419.62	70.98
Gas	305.10	15.26
NH_3 gas	6.41	.32
Liquor	141.20	7.06
Tar	101.80	5.09
Light oil	23.04	1.15
Total	1 997.17	99.86

In deriving the true yields, the following items were considered and correction made therefor:

Gas—Oxygen equivalent to 0.3 per cent; moisture absorbed at washers, etc.

Ammonia—No corrections.

Liquor—Correction made for infiltration of water by drainage, cooling water, etc.

Tar—Corrected for moisture content; wash oil and benzol still residues.

Light oil—No corrections.

Coke—Rechecking of screening, credits, etc.

A comparison of actual analyses of various products with those given in the distribution of elements and their subsequent grouping is of interest:

Coke	Derived per cent	Actual per cent
Moisture	0	2.50*
Volatile matter	0.66	0.74
Fixed carbon	87.76†	87.50
Ash	11.52‡	11.76
Sulphur	.96	.89

*Moisture absorbed in quenching.
†All carbon in fixed carbon.
‡Sulphur and nitrogen included in ash.

Gas	Derived per cent by volume	Actual
CO_2	1.60	1.8
CO	8.37	6.0
CH_4	33.73	33.1
Ill.	3.98	3.4
N_2	1.00	4.0
H_2	46.69	51.3
O_2	1.63	0.4
	100.00	100.0
Hydrogen sulphide	0.6 lb. per M. cu. ft. gas	0.61 lb. per M. cu. ft. gas

The other products are not comparable in terms of analysis.

In making the above study, the thought arises that the reverse of the process gone through herein is first necessary to obtain the proper distribution of elements throughout the carbonization. A knowledge of the products is undoubtedly necessary to isolate the individual elements.

However, having once obtained the complete analysis of the entire process for a given coal, an ideal can be derived, in addition to a more intimate knowledge of the intricacies of the reactions involved.

Steel Group Organized in Pacific Northwest

The organization of structural steel fabricators and steel and iron foundries of the Pacific Northwest will afford solution of many trade problems. The object will be to foster co-operation and a better understanding among the various groups constituting the membership. E. C. Pape of the Williamette Iron & Steel Works, Portland, Ore., has been elected president of the newly formed conference. T. A. Stevenson, manager Tacoma chamber of commerce, is acting as secretary. The following group committees elected chairman as follows and have submitted reports and recommendations: Steel fabricators, R. N. Allen, of the Star Iron & Steel Company, Tacoma; steel foundrymen, E. R. Hinton, of the Olympic Steel Works, Seattle; iron foundrymen, E. J. Mann, of the Independent Foundry, Portland; steel pipe and tank group, F. C. Kind, of King Bros., Portland.

Elimination of Coke Plant Accidents*

Safety First Work in Coke Oven Plant at Joliet Given Recognition in 1908—By Close Observation of Habits and Actions of Men Many Accidents Are Prevented

By GEORGE P. WARD†

THE by-product coke industry had its inception in this country in 1892 with the construction of a modest little unit of 12 ovens in connection with the Solvay Process Company's plant in Syracuse, N. Y. While it did not meet, at that time, with any ill will on the part of users of metal coke and the beehive operators, nevertheless, it did maintain a growing interest, although its growth was slight.

When the interest of the steel corporation in 1908 culminated with the Koppers' oven, the by-product ovens received added importance among the steel producing units, so that soon it was recognized as a necessary unit of any producing plant. Not alone in the field of domestic fuel, gas and coke, has it been acceptable, but the by-product coke oven industry has become one of major interest.

It is a singular fact that it was in the Joliet Plant of the Illinois Steel Company that the by-product oven industry, in 1908, recognized by importance of safety work, by the appointment of the late Captain H. B. Smith as a safety leader.

May I pause for a moment to pay a tribute to one who saw the silver lining of safety in the dark clouds of industrial accidents when it was not so clear to others? Behind the curtain of an abrupt manner this man had a heart of gold; stern and uncompromising in his efforts to reduce the unsafe practices of those days, he trod his path without the sympathy of many whom he sought to aid. Many of the coke-oven men who received their early training at Joliet have a vivid recollection of his persistence in making them pass a safety examination from a rule book. They looked upon him then as somewhat of a fanatic and a tyrant. But we look back upon this pioneer now as an evangelist of a new doctrine, "Thou shalt not maim or kill," and I pay my little psalm of praise to that man who helped to raise the dark cloud from industry.

If we are to discuss the elimination of coke plant accidents, it might be advisable briefly to consider the hazards in this industry. A coke plant handling 2000 tons of coal a day will find it necessary to load and unload 85 to 100 cars of material. The loading, unloading and moving of this many cars of different types of material necessarily brings many risks. In the oven operation in the curbing and conveying of 2000 tons of coal a day, with its elaborate, mechanical, electrical equipment, we find many hazards. In the oven operation, we not only have the mechanical and electrical devices, but additional risk of handling hot material, such as coke and burning gases with the danger of explosion.

In the by-product department, including the benzol plant, again we have the mechanical and electrical devices, together with the chances of burns from steam, tar, acid, lime, caustic soda, noxious and poisonous fumes and explosive liquids; so that I realize the coke oven industry is in much need of safety precautions and devices.

The builders of the modern coke oven plants have co-operated with the operators and with the manufacturers of auxiliary equipment, to produce as safe an operating plant as they possibly can, and they have succeeded reasonably well with the limits of experience and foresight. But as no one has been able to protect a careless man against himself, it is this element which we must perfect, if we are to eliminate coke plant accidents and it is this phase which I propose to discuss.

This is a story of our plant. Beginning in 1912 we had 55 lost-time accidents; in 1913, 52; in 1914, 22; in 1915, 15. In 1916 and 1915, I might say, operation had been decreased and the number of men had been decreased, and at that time we made a particular drive to see if we couldn't do something; we succeeded to that extent. But with war activity developing in 1916, and with the added operation at the plant, we found ourselves slipping and again went to the 30 mark. We pulled up a hole in our belt and started after it again and found we came down to 15; and by keeping after this thing, we were able to maintain 15 in 1918. In 1919 we dropped down to 13; and then in 1920, with the reaction of the strike and hiring a lot of new men, we went back to 15. In 1920 and 1921, we were not doing very much, the number of men we had dropped down to four and three.

Then in 1923, with a lot of colored and Mexican labor, and in striving to get our production out, we slipped and went back up to seven. Again we went after this thing and in the following years we find ourselves with two and two, and in the last two years, we find ourselves with none. In other words, from Labor Day of 1925 until the present moment, we have had no serious accident that has caused the loss of a single day's time.

It is an interesting part of this, that in the first three years of this five-year period while we were able to limit the minor accidents of one to seven and eight to 10 days, we suffered each year two of the more serious accidents.

In trying to find a reason for that, we found that all of those accidents had occurred in the operating department. Previous to that period, the repair and the maintenance labor and operating labor had been a 50-50 break, or in proportion to the number of men employed in the plant. When we got down to this period, the repair and maintenance had succeeded altogether in stopping their accidents and the operating department had not. What was there in that that might give us some clue? In studying it over, we came to several conclusions.

One of them was that the repair man is not always called upon to hustle as much as the operating man.

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*Paper delivered before Sixteenth Annual Safety Congress, Chicago, Ill.

†Superintendent of coke plant, Joliet Works, Illinois Steel Company, Joliet, Ill.

He has a chance of taking a little more time at the job he has to do and if it is a large break-down, invariably the foreman is there with him.

Another thing that entered into it was the question of whether the monotony of the operating man, having to do the same thing over and over again, had any influence on his becoming careless. The repair man did not always have the same job, but had one hour at one end of the plant, another hour at the other end of the plant, each time on a different type of apparatus, and consequently this might have some bearing upon the problem.

Then another thing that entered into that was the question of the operating man having to stay on his job up until the last moment of quitting time, where the repair man could possibly time his job to get through a few minutes before quitting time and be prepared to go home. The operating man who had to stay until the last minute, might have a tendency to hustle up and in that congestion produce an accident.

That is our story. That is what thus far we have accomplished.

Now, what are the tools with which we work? Being a department of a large plant, we are necessarily a part of the general safety organization. That has its value in that the safety department, being alive to safety, will concentrate and focus our attention sometimes on conditions which otherwise might not receive the consideration due them. We get, too, from this general safety organization, reports, service of their inspectors and committees from other departments, safety campaign slogans, etc. In our general safety organization, we have one man classed as an inspector whose duties are mainly those of an instructor. I don't believe this man is common to the general safety organization, but it is his duty to make contact with the newly hired man on the job as soon as possible. He takes to him a message of safety, the value of safety to himself and to his fellow workmen, his obligation to his foreman in reporting unsafe conditions and practices. Coming from the outside, he necessarily feels he has a big value in giving to that man a conception of safety.

While the details of this operating job necessarily fall upon his foreman, nevertheless this instructor may be used as a liaison between the foreman and the man, if he happens to be a foreigner, since this instructor can speak several languages. I don't believe we can over-estimate the importance of that man.

Then again, he talks to the older men in the line of safety, men of the less skilled classifications, and holds a safety meeting with our big button men; and these big button men are selected in different groups to be the safety leaders in that particular group.

I might call attention for just a moment, to the fact that our general safety organization is a live organization. We feel that a good bit of our success has come from the co-operation and the assistance of that general organization.

In the whole plant, employing 2400 men a day, 169 days have now passed without a single lost-time accident and that credit goes mostly to the general organization. We have our own department organization with committees having the function of investigation and inspection, but more and more we are coming to believe that if accidents are to be eliminated in our coke plants, the foreman is the man who is going to do it. A committee may investigate an accident and recommend something to prevent a like accident, but an observant foreman might have prevented the original accident. The foreman is in daily and hourly contact with his men and consequently is in a position to detect a false move in the human equipment, as he is in position to detect a false note in the mechanical equipment.

We are insisting upon our foremen developing the habit of observation. Not a casual inspection of his work, but a close observation of the man at his job; because we feel that if he will do that, there will come in that man's action, possibly some clue to an accident that might develop later on. Just the other day one of the foremen came to me and said, "I had a man come to work this morning and I noticed that part of his shoe was either torn or cut out and I said to him, 'I want you to be careful today; and tomorrow I want you to wear a better pair of shoes. I don't want you to wear that kind because you are liable to have a burn.'" It wasn't two hours later until that man accidentally burned his foot with hot water, but fortunately it was a very minor burn.

We feel that near accidents are a clue to most of the accidents which happen, that in every serious accident which has occurred there has been a parallel in a near accident if we have been sufficiently observant to find it. How frequently when an accident has occurred have we heard such a man say, "I knew such-and-such a thing was going to happen because so-and-so was doing such-and-such." We don't hear that in our plant any more because we have tried to show our men that they owe it to themselves, just as much as they do to the fellow workmen, to report these little slips so that the foreman or the department superintendent can analyze the near accidents and see in them the possibilities of graver and more serious accidents. The foreman is in a better position to hear these things. It is difficult to have the men report these near accidents, quite difficult sometimes to have the foreman report them; but being in daily and hourly contact with his men, if he is an observant foreman, then we feel he is going to be in a much better position to find and catch these near accidents and from them enable us to learn a lesson.

Naturally, if we are going to put the burden of responsibility for eliminating accidents upon the foreman, we should assist him in every manner possible. That is our job and one of the ways that we have of assisting our foreman is in a safety letter. Each foreman is compelled every month to send a safety letter to the department superintendent. He is supposed to say that he talked about specific subjects to the men in his group. We have a way of checking that up, either by this instructor or by some other man going out to a man in a certain group and finding out whether that particular foreman has talked to him about a specific subject. This gives the foreman an opportunity to protect himself because if he has talked to his men on a specific subject and he has so reported, should an accident occur along that line, he has a written record that he can refer to. Sometimes this saves him criticism and possibly censure and maybe discipline.

Not long ago we had a case of a man at the change of turn, who had been warned that when the wind was in a certain direction and the steam hid the coke side of the walk, that it was dangerous for him to walk along that side and that he should use the steel work as a guide and go on the other side. The change came about 11 o'clock. He was in a hurry to go home. Conditions were bad. He didn't walk, he ran and fell off the walk. The result was a broken leg. The foreman was able to produce his written record that he had given specific instructions about that particular thing, so that there was no censure for the foreman at all. But since that time, as the winter comes along when these conditions prevail, we go to that foreman and recall to his mind the fact that that accident happened several years ago and that it is liable to happen again. We suggest that, besides telling the man of the condition and that he must not do that, if he is wise he will watch all his men at the change of turn, and see if they violate that rule or not. Thus he will be able to catch an unsafe practice which might result in a very serious accident.

When we receive a report of an accident from another plant, whether it comes from our general safety organization or from some visitor, we immediately transmit it to the foreman so that he knows about the type of accident, and if he has any conditions corresponding to that, he can be governed accordingly.

Then it is customary for us, ever so often, to review the accidents which we have had and to call the foreman's attention in the different departments accidents which have happened as much as five, six, seven and eight years ago. In this way we check up on conditions surrounding such accidents and see whether there exists at the present time the possibility of a repetition.

In the six serious lost-time accidents which we have had in the last five years, only one of them indicated any failure of mechanical equipment, and I am not sure that was so much the failure of mechanical equipment as it was the failure of the man to treat the mechanical equipment in a fair manner. True enough, we will try to fix it so that even though it were treated in the same way again, that same accident could not happen.

Three of those serious accidents happened either at the beginning or at the end of the turn, indicating that the men were in a hurry to go home and were taking chances, or that the man coming on to the job was in a hurry to get his operation started and took a chance.

Two of these serious accidents happened at an abnormal operating period. In other words, the operation at that particular time was not normal and smooth as it usually is, but had piled up. It was necessary to hustle up, and these men, in hustling, in trying to do their work, made a false step, allowed themselves to get away from the safety instructions and a serious accident resulted.

So, as we review these things, we feel more and more than the accident elimination in the coke plant is going to come through a very close supervision of our men. That if we will closely observe them, not alone in the normal operating period, but will observe their actions under stress or under conditions of hurry, that we may find in that period some indication that later on will produce an accident.

Paraphrasing the comment of Will Rogers to a politician, "Accidents do not happen, they are brought about." So far as I feel now, the main man in helping to eliminate accidents in the coke plant is the foreman.

Eleven Electric Slaves for Each American Family

The estimated output of nearly 80,000,000,000 kwh. of electric power for the United States in 1927, if it could be converted into equivalent man power, would provide the average family of about four persons in the United States with the services of 11 able-bodied mechanical laborers working eight hours daily, including Sundays and holidays, at a total cost for the 11 of about $75 a year.

The total production of electricity by public-utility power plants in 1927 is estimated by the Department of the Interior, through the Geological Survey, at about 79,700,000,000 kwh., an increase of about eight per cent over the output for 1926, which was 73,791,000,000 kwh. The estimate for 1927 is based on reports of monthly output of electricity by public-utility power plants for the 11 months January to November and estimated figures of output for December. The latest monthly report, released January 4, contains the figures of monthly output for September, October, and November.

Sheet Steel for Automobile Bodies

(Continued from page 622)

precipitation of the eutectoid of cementite plus ferrite into "pearlite."

Thus up to this point our ferrite has been precipitated out leaving a mixture of Fe_3C and the ferrite in a definite proportion. As our carbon content is small (only .10 per cent) the steel will contain only about 1.5 per cent cenemtite which combines with about 10.5 per cent ferrite (ratio seven parts ferrite to 1 part cementite) to form 12 per cent pearlite. Theoretically this leaves 88 per cent free ferrite which must be rejected from the original grains of primary austenite before the eutectoid or "pearlite" is precipitated and as a result are between these resulting grains of pearlite at A_1 thus completely surrounding them. It is not necessary to illustrate this phenomena again but to more completely understand this final structure the reader should again study Fig. 3, noting the pearlite completely surrounded by grains of free ferrite.

After this precipitation of the eutectoid called "pearlite" the cooling continues to room temperature without any structural change. With the tensile strength gradually increasing until at room temperature the sheet steel (in the form of sheet bar) reaches about 40,000 lbs. per sq. in. An elongation of approximately 30 per cent in a 2 in. test strip, and a Rockwell hardness of about 50.0 to 60.0 as measured with a 1/16 in. ball and 100 kg. weight.

In general it may be said that this represents the maximum softness of sheet steel at this point of its process. As the carbon content increases (from .01 to .15 per cent) the per cent elongation in 8 in. will decrease from about 32 to 22 per cent and the tensile strength will increase from 38,000 lbs. per sq. in. to 50,000 lbs. per sq. in. These figures are approximate only and are merely included to give us an idea of what sheet steel at this point will physically show. These properties are lost and regained as the steel is made into sheet form.

(To be continued)

SPRING MEETING PROGRAM

of the

American Society of Mechanical Engineers

Pittsburgh, Pa., May 14 to 17, 1928

Monday, May 14

Morning: 9:30 A. M.
Council Meeting
Conference of Local Sections' Delegates

Afternoon: 2:00 P. M.
Council Meeting
Simultaneous Sessions

Fuels and Heat Flow

Auspices of Fuels, Iron and Steel and Power Divisions

"The Flow of Heat Through Furnace Hearths," J. D. Keller.

"Use of Pulverized Coal in Basic Open Hearth Furnaces," E. L. Herndon.

"Combination Firing of Blast-Furnace Gas and Pulverized Coal," F. G. Cutler.

Management

Jointly with Pittsburgh Section, American Ceramic Society

"Systems of Workman Payment in Porcelain Factories," H. N. Kraner.

General

"Reciprocating Dry-Vacuum Pump," W. S. Weeks and P. E. Letchworth.

"Plate Steel Rotor Design for an Electric Generator," H. G. Reist.

"Training Minor Executives in a Rapidly Growing Organization," A. J. Beatty.

4:30 P. M.—Business Meeting

Monday Evening—Informal Entertainment

Tuesday, May 15

Morning: 9:30 A. M.
Simultaneous Sessions

Seamless Tubing

Auspices of Iron and Steel Division

"The Manufacture of Seamless Tubes," R. C. Stiefel and George A. Pugh.

Hydraulic

"A Long Distance Recording Water Level Gage," E. B. Strowger.

"Computation of the Tail Water Depth of the Hydraulic Jump in Sloping Flumes," Robert W. Ellms.

Railroad

"Locomotive and Freight Car Utilization," C. B. Peck.

"Power Brakes and Modern Train Operation," L. K. Sillcox.

"Locomotive Sparks," L. W. Wallace (By title).

Afternoon—Inspection Trip

Train ride through plants of the U. S. Steel Corporation

Wednesday, May 16

Morning: 9:30 A. M.
Student Branch Conference
Simultaneous Sessions

Machine Shop Practice

"Some Common Delusions Concerning Depreciation," Ernest F. DuBrul.

"Ball Bearing Machine Tool Spindles," Thos. Barish.

Applied Mechanics

"The Theory of the Dynamic Vibration Absorber," J. Ormondroyd and J. P. DenHartog.

"Theory of Strength of Steel Columns," H. M. Westergaard and W. R. Osgood.

Glass

"Some Recent Improvements in the Manufacture of Flat Glass," H. L. Hitchcock.

Engineering Education

"Industrial Co-operation in Education," A. T. Jewett.

"Education and Training as Applied to the Engineer," F. L. Bishop.

Afternoon: 2:00 P. M.—Student Branch Luncheon
Inspection Trip
Westinghouse Electric & Mfg. Company.
Evening—Dinner
Award of Holley Medal to Elmer A. Sperry

Thursday, May 17

Morning: 9:30 A. M.
Simultaneous Sessions

Materials Handling, Jointly with Management

"A Material Handling and Transport Organization," C. A. Fike.

Central Station Power

"Some Economic Factors in Power Station Design," H. B. Brydon.

"High-Pressure Steam Boilers," Geo. A. Orrok.

Alloys

"Mechanical Properties of Aluminum Casting Alloys at Elevated Temperatures," R. L. Templin, C. Braglio and K. Marsh.

"A Study of Tin-Base Bearing Metals," Part I, O. W. Ellis and G. B. Karelitz.

Applied Mechanics

"Torsional Stress Distributions in Prismatical Bars," L. S. Jacobsen.

"Stresses in the Drive System of Three-Cylinder Locomotives," F. Loewenberg.

Afternoon—Inspection Trip

American Window Glass Company, Jeannette

The POWER PLANT

A Combined Boiler and Producer Plant

Sharon Steel Hoop Company Generates Steam and Gas in Central Building—Arrangement Assures Efficient Service and Is Economically Attractive

By **CHARLES LONGENECKER**

SINCE 1924, the Sharon Steel Hoop Company has been putting into effect an extensive program of reconstruction at its Sharon plant. This company became a producer of steel products in 1901, hence it was inevitable that, like other companies that have been in existence for any considerable period, partial reconstruction would eventually be necessary. Such a revamping is demanded by the inexorable laws of progress which cannot be disregarded if plant stability, quality of output and economy of operation are to be maintained.

Practically every department in the plant has undergone rehabilitation either partially or completely. A new machine shop has been erected, a power plant put in service, a slab and billet storage building for steel held in stock, has been added; old furnaces have been replaced by more modern ones and a boiler and gas producer house, admirable in design, now furnishes steam and producer gas. Other additions in course of erection will afford the company ample facilities for pickling and for cold rolling strip steel, etc.

Great care has been exercised in the design of all new units in order that they should meet plant requirements in the most approved manner. This end has been achieved and especially so as regards the boiler and gas producer plant.

Before the present boiler and gas producer plant was placed in service, steam and gas were furnished by 17 Sterling stoker fired boilers and 12 hand poked producers. This equipment has been replaced by two 500 hp. Sterling boilers and four 10-ft. diameter Morgan producers, all housed under one roof. Whereas it was necessary to supply steam for power, this condition no longer prevails due to the fact that all mills, with one exception, the 10-in. roughing mill, have been electrified. Outside of this one exception, all steam now generated is used for heating, for agitating the pickling vats, and for blowing the producers.

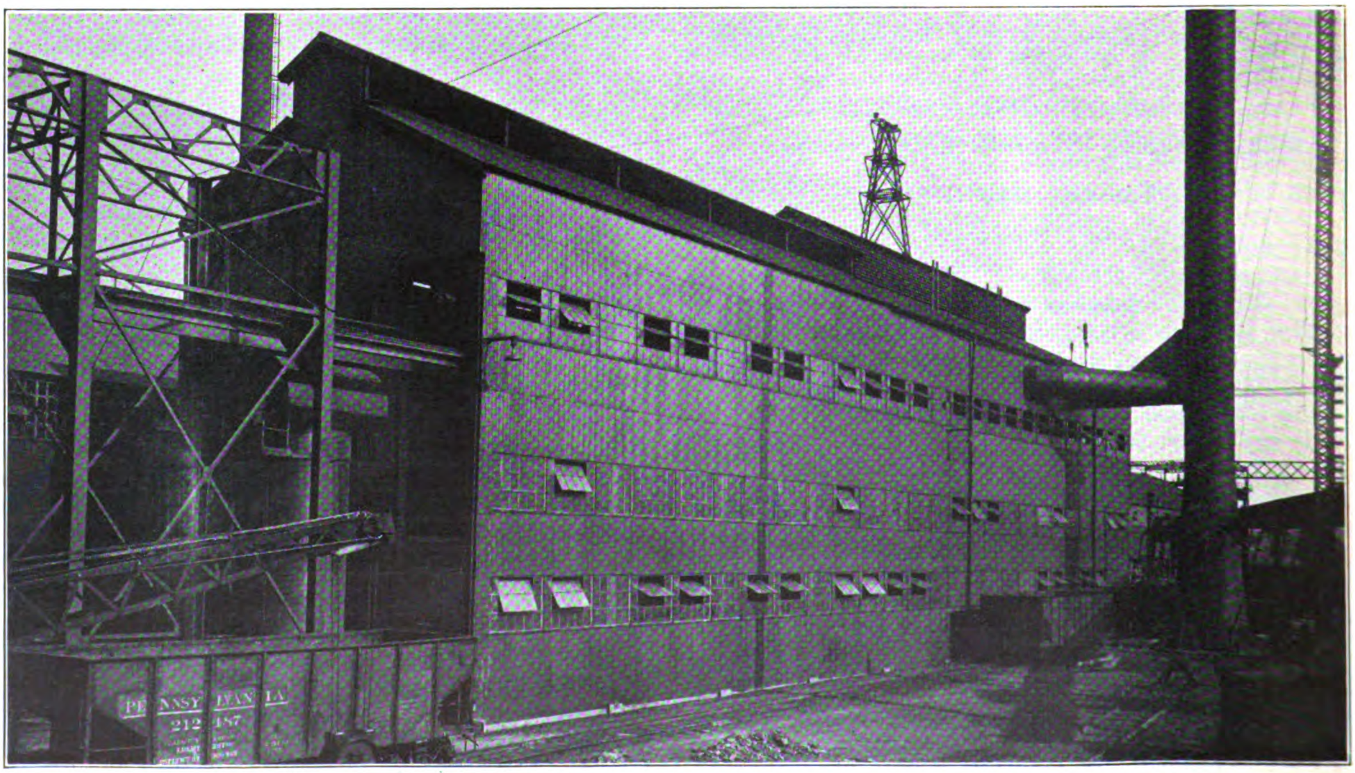


FIG. 1—Building housing boilers and producers.

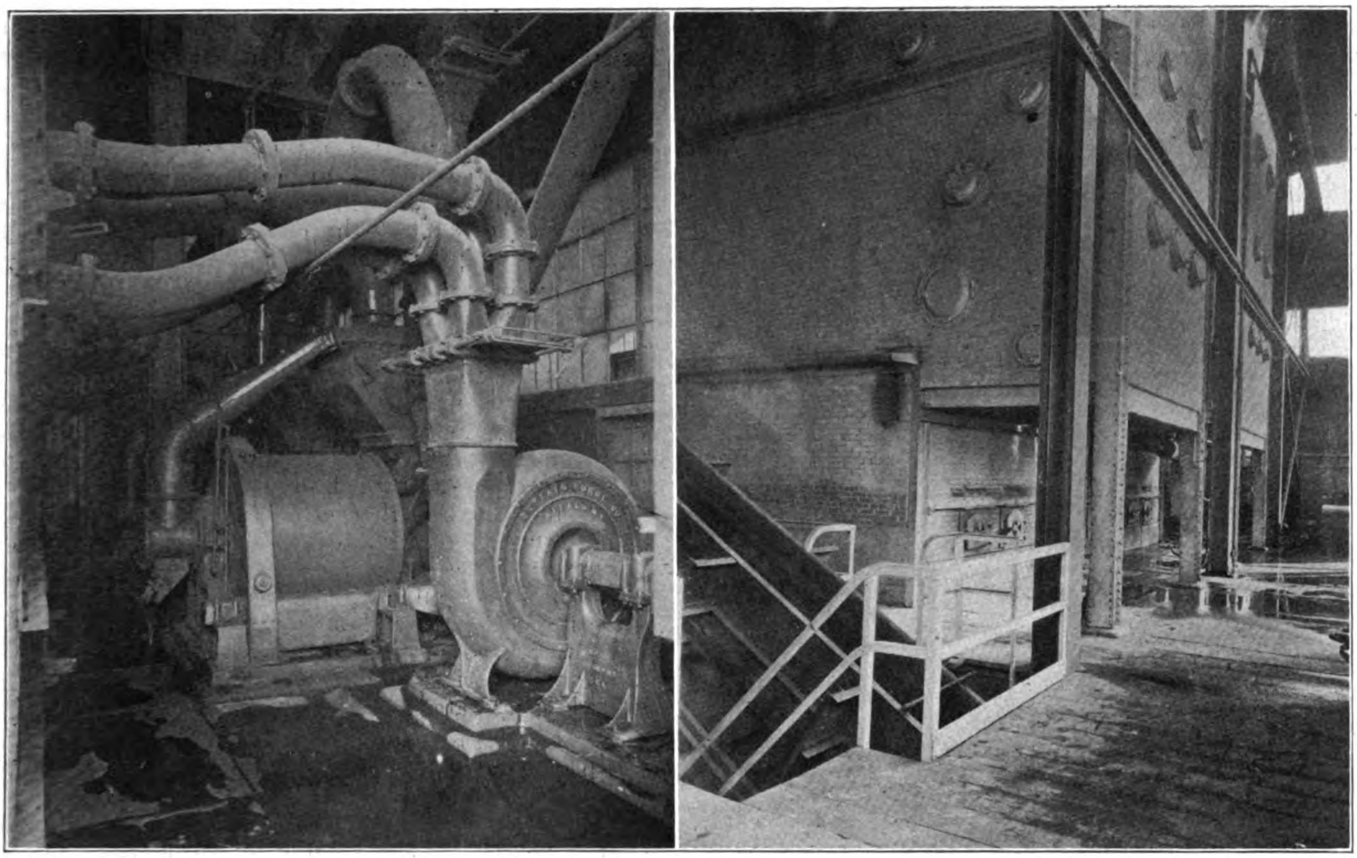


FIG. 2 (left)—View showing arrangement of pulverizing mills, exhausters and burner piping. FIG. 3 (right)—View showing rear of boilers.

By placing the producers and boilers in the same building their care and operation is much simplified. Thus, in the handling of coal all unloading and delivering is confined to one point instead of several, as was formerly the case. Furthermore the labor for supervision and operation is greatly reduced; instead of a crew of 54 men at the gas producers, only six are now required, while a proportionate reduction has been made in the boiler house force. Other incidental advantages are greater economy in maintenance, increased efficiency and much less difficulty in the disposal of ashes.

Boiler and Gas Producer Building

At the right of the combined power and gas house, as shown in Fig. 1, are the stack and flues for carrying off the waste gases from the boilers. This steel stack has a height of 225 ft. with a top and bottom diameter of 8 and 12 ft. respectively.

Beneath the steel car adjacent to the stack is the entrance to the concrete hopper, the top of which is covered by grizzly bars. From this hopper the coal passes onto a scraper conveyor and is discharged into a crusher placed at the base of an elevator. That portion of the building set aside for the boilers has a length of 88 ft. (4 bays at 22 ft.) and for the gas producers a length of 100 ft. (5 bays at 20 ft.). A producer has been placed in each of the four 20 ft. bays, but provision has been made for installing a fifth in the unoccupied bay. At the boiler end of the building the width is 54 ft. and at the producer end 42 ft.; the height to the eaves is 50 ft.

Ventilation, always a most important feature, especially in a building containing gas producers, has been assured by ample monitors and well controlled air admission through openings at three levels in the sides of the building. Through these openings and the sash surrounding them, light is admitted in such sufficiency that artificial light is not necessary.

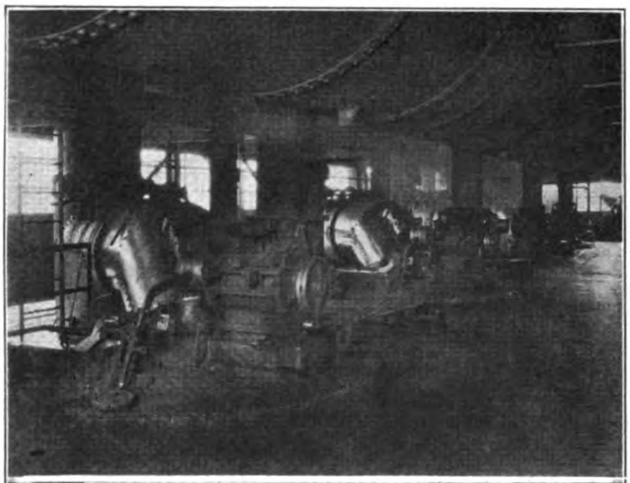
Coal Handling Equipment

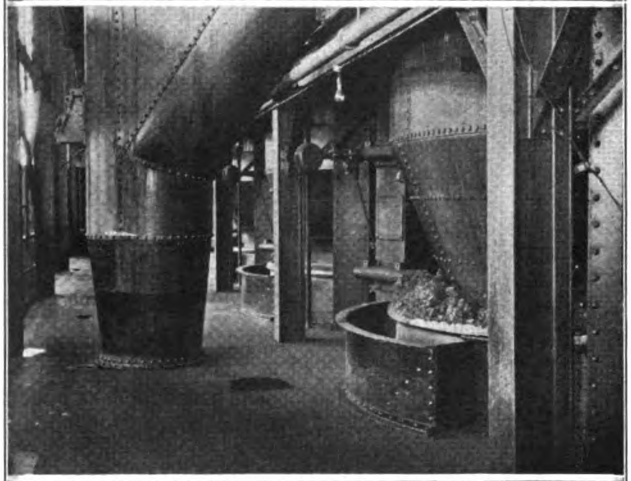
As the coal cars are received they are shunted to either the storage yard or to the track passing along the building. This track has a length, beyond the coal hopper, sufficient to permit the placing of three cars so that when one car is emptied another is released and moved by gravity to replace it. From the boot of the elevator the coal is raised and discharged onto an inclined stationary screen made of steel flats so assembled that the size of openings can be varied. Usually the flats are set so as to give an opening from ½ in. to ¾ in.

The coal that passes through the screen falls upon a scraper conveyor which carries it over the hopper above the pulverizers. By the movement of suitable slides beneath the conveyor the coal is allowed to drop into any section of the hopper. In this hopper 300 tons of coal can be stored.

All coal that flows over the screen is deposited upon a belt and is then conveyed to a 700-ton capacity storage bin, the bottom of which can be seen in Fig. 4. Frequently considerable difficulty is experienced in obtaining the weight of coal consumed in plants where distribution is made from the car to two, or more, points of consumption. This difficulty has been overcome in this instance by the insertion of a scale between the screen and the first point of discharge into the bin. By subtracting the weight of coal passing to the producers from the total car weight, the amount going to the boilers is determined.

In addition to the storage capacity afforded at the boilers and producers, sufficient space has been provided in the mill yard for the deposit of enough coal to last for some months. An analysis of the coal delivered to both the boilers and producers is sul. 1.35 volatile matter 36.39, ash 6.77 fixed carbon 53.82, moisture 3.02.





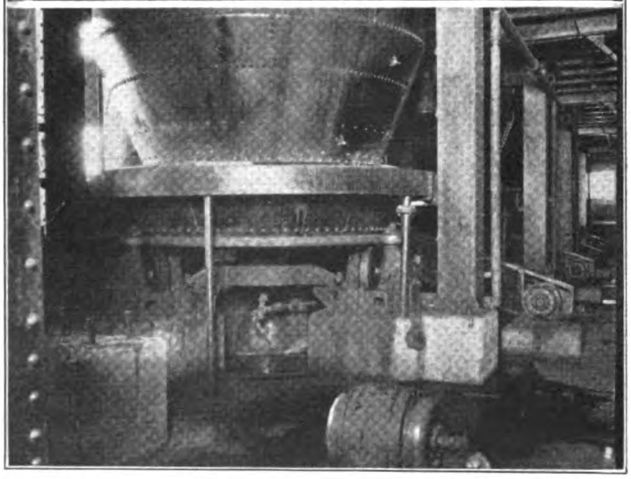


FIG. 4 (top)—Floor at top of producers. FIG. 5 (center)—Ash discharge floor. FIG. 6 (bottom)—Floor at bottom of producers.

Boiler Department

There are several features of more than passing interest in connection with this boiler installation. Firing boilers with powdered coal is not at all unusual, but the manner in which this method of firing is carried out here makes it very attractive.

All coal that reaches the pulverizers is quite uniform in size since it has passed through a screen, and furthermore, it contains no pieces of metal which are large enough to interfere with the feed of coal. Thus, the feeding of coal to the machines is simplified and disintegration promoted.

Located in the front wall of each boiler are four horizontal flare type burners which are supplied with coal by a ball type pulverizer capable of furnishing 4000 lbs. of coal per hour. From the pulverizer the coal is drawn into a fan and is then discharged into a distributor to which are connected the four pipes to the burners as shown in Fig. 2. The two pulverizers are cross-connected in order that both pulverizers can furnish coal to either one of the boilers and thus permit one boiler to carry the entire plant load in case the other boiler is out of service. This arrangement of direct pulverized coal firing affords a maximum flexibility throughout the operating range of the boilers. Moreover, due to the compact and accessible arrangement of the equipment, only one man is required to operate it.

A steam pressure of 150 lbs. and a rating of from 200 per cent to 250 per cent is usually carried on the two 501 hp. Sterling boilers during the winter months, but this rating can readily be increased to 300 per cent if desired. At 175 per cent rating the CO_2 will average 13 per cent while the stack temperature will approximate 550 deg. Both boilers are equipped with soot blowers, flow meters and recording instruments for measuring stack temperature.

Ashes are removed from the combustion chamber through two doors in the rear of the settings as shown in Fig. 3, but there are also doors in the front wall which can be used for a like purpose. By means of a chute, hidden by the columns in Fig. 3, fine ash which collects in the final boiler passes, can be discharged into a wheelbarrow.

Water for the boilers is pumped into a 290,000 gallon tank from the Shenango River which flows close to the plant. This water is treated by adding 36 lbs. of phosphate and 18 lbs. of soda ash every 24 hours. A daily analysis shows on an average, per million parts:

Caustic	140
Alkali	202
PO_4	40
SO_4	1680

From the tank the water passes into a feed water heater, through feed pumps and into the boilers.

Gas Producer Department

This producer plant is exceptionally well designed and eminently satisfactory in the service it renders. The building is especially well fitted for its purpose and the equipment within it is disposed so as to give it full opportunity to operate at highest efficiency. Figs. 4, 5 and 6 are views of the machines on the three elevations.

There are four producers, each of which gasifies about 3500 lbs. of coal per hour. These furnish gas to individual furnaces at the 8-ft., 9-ft., 10-ft. mills and

Boiler and Gas House Equipment

Buildings	Pittsburgh Bridge & Iron Works
Coal handling	Heyl & Patterson Corporation
Boilers	Babcock & Wilcox Company
Pulverizers, burners, etc.	Fuller-Lehigh Company
Gas producers	Morgan Construction Company
Gas producer regulator	Chowning Regulator Company
Pyrometers	Brown Instrument Company
Gas piping	Duff Patents Company
Fans at pulverizers	Buffalo Forge Company
Soot blowers	Diamond Power Specialty Corporation
Coal scale	Merrick Scale Manufacturing Company

All equipment erected by Sharon Steel Hoop Company

to two furnaces at the 14-ft. mill. An average analysis of gas will run:

CO	23.26
CO_2	5.8
CH_4	4.14
H	14.46
N	52.04
O	0.1

The gas flows from the producers into a gas main which can be seen to the left of the building in Fig. 1. At this point it has a diameter of 8 ft. inside plates, but this is reduced to 6 ft. 6 in. between the second and third producers. It is lined with 4½ in. of fire brick and 2½ in. of insulating brick. For some distance after leaving the building the pipe passes partly below ground level, and for this distance a concrete trench has been constructed; while at frequent intervals along the entire length of the pipe, clean-out bells have been installed and made accessible. From the producer house to the point where the pipe branches to the different furnaces the length of the line is approximately 130 ft.

In order that the pressure of the gas in the line may be kept constant a Chowning regulator has been installed near the producers; the temperature of the gas is recorded by a pyrometer.

Ash disposal, which is in many cases a troublesome feature, is here well and adequately accomplished. Fig. 5 shows the manner of removing the ash from the producer by the plow. From the producer it falls into the steel bottomless box and then into a concrete pit the wall of which, next to the producer, has a slope of 50 deg. to the horizontal. This pit which extends the full length of the producer building, has a depth of 13 ft. below ground level and a width of 6 ft. 6 in.

Ashes are removed from the pit by a transfer crane whose runway is not only above the pit, but which also extends beyond it to the rear of the boilers at one end, and into the yard at the other end. These extensions of the runway appear in both Figs. 1 and 3. A clam shell bucket suspended from the crane picks up ashes either at the rear of the boilers or in the producer pit and deposits them into a railroad car placed under the crane runway outside the building.

Labor Required at Producers and Boilers

Both boilers and producers are under the supervision of a general foreman, who personally directs operations during the eight hour day turn. On this turn all coal required for 24 hours is unloaded and placed in the hoppers by an elevator operator and two helpers. The boilers are tended by one man on each of the three turns and the producers by one gas maker and a helper on each turn.

Electrical Control

With the exception of the feedwater pumps, all equipment in both departments is electrically driven by current supplied at 220 volt, 60 cycle, 3 phase from substation in the plant. This substation is connected with two outside circuits that deliver current at 66,000 volts. All controls for motors in the producer and boiler houses are of the remote type and ample provision has been taken to assure continuous operation.

General

The output of the Sharon plant of the Sharon Steel Hoop Company is high quality strip steel such as required in the manufacture of automobiles; in fact about 75 per cent of the company's output which approximates 220,000 tons per year, is sold for this purpose. Besides the plant at Sharon the company has one blast furnace and six open hearth furnaces together with a blooming and slab mill at Lowellville, Ohio, and a sheet mill at Youngstown, Ohio.

A Metallographic Atlas

A series by Prof. H. Hanemann and Miss A. Shrader, published by Gebruder Borntraeger, Berlin, Germany, has appeared in the first two sections. The first section with plates 1-8 illustrates and describes various ferrous compositions from pure iron to common steel of .64 carbon, while the second section with plates 9-16 includes common steel grades from .56 carbon up to 1.48 carbon. The microphotographs are of excellent technical quality and serve as a standard for comparison in the study of grain structure. The "Atlas" will eventually cover typical structures of metals and alloys.

Waste Heat Recovery from Open Hearth

An Easily Comprehended Discourse, from the Theoretical and Practical Viewpoint, on the Service Rendered by Waste Heat Boilers

By T. J. ESS

IN line with the general striving in all industry toward economies in production, throughout the steel industry every effort is being made to increase plant efficiency and to effect savings which will tend toward lower production costs. Not the least important step in this direction is the general application of waste heat boilers to open hearth furnaces, notoriously low in thermal efficiency. The steam thus generated is usually used for fuel atomization, gas producers, or process work, and in some cases for power generation.

Waste gases leaving the checker-work of well designed open-hearth furnaces carry from 35 to 55 per cent of the heat of combustion of the fuel fired, averaging toward the upper limit, and depending on furnace size, operation and practice, volume of checker-work, and kind of fuel used. With good design and operation of waste heat boilers, approximately 55 to 65 per cent of the heat in these gases is recovered and converted into steam, representing 20 to 35 per cent of the heat of combustion of the fuel fired in the furnace. The value of the coal thus replaced for steam generation is usually credited back to the open-hearth cost, and, where all available waste heat from the open hearth is used, operating averages show a saving of 150 to 200 lbs. of coal per ton of steel made. With coal at $3.50 per ton, this gives a credit to the open hearth of 27 to 35 cents per ton of steel.

Heat Available

The heat thus transmitted to the waste heat boiler is found by the following formula:

$$H = W\ (T_1 - T_2)\ s \qquad (1)$$

where H = Btu. per hour, W = lbs. of gas per hour, T_1 = temperature of gas into the boiler, deg. F.; T_2 = temperature of gas out of boiler, and s = the specific heat of the gas, Btu. per lb. Dividing H by 33,480 gives the boiler hp. to be expected.

The temperature of gases into the boiler (T_1) usually runs from 1000 to 1300 deg. F., depending on practice, checker-work, and size of furnace. Well designed waste heat boilers will cool the gases to give an outgoing temperature (T_2) of 460 to 500 deg. F.

The quantity of gas depends on the size of furnace, kind of fuel, combustion practice, type of charge in the furnace, moisture in the air, etc. Table I gives the total weight of gases to be expected for various fuels, together with the heat content above the boiler stack temperature, and the amount of steam generated therefrom. The table is based on typical practice as follows: 6,000,000 Btu. in fuel per ton of steel, burned with 100 per cent excess air; fuels of typical analyses and characteristics were used; temperature of gas to boiler was assumed constant at 1100 deg. F., and temperature of gas out of boilers at 480 deg. F. Specific heat was used as .24 for dry gases and .48 for moisture in the gases. An average calculated amount of gas from the bath, etc., was included in the weight of gases. Steam generated was calculated at 95 per cent of the heat extracted from the gas in the boiler, thus allowing 5 per cent for radiation.

It will be noticed that the heat recovery from producer gas stands considerably above that from the other fuels, due to the lean nature of the fuel, with its accompanying high stack loss.

While Table I gives an idea of the influence of the kind of fuel upon the results to be expected from waste-heat boilers, it should be mentioned that the various assumptions made in calculating the table do not necessarily remain constant with changes in fuel in a given installation. A given furnace, operating on producer gas, and producing steel with a fuel rate of 6,000,000 Btu. per ton, may, with natural gas as fuel, produce steel at 5,700,000 Btu. per ton, while the stack temperatures may change. For example, the same furnace, producing alloy steel of high quality, used 7,000,000 Btu. per ton with oil as fuel and with cold pig iron, 6,100,000 Btu. per ton with oil and hot pig iron, and 5,800,000 Btu. per ton with coke-oven gas and tar and hot pig iron. Such variations may be due to better means of control, more efficient combustion apparatus, etc. However, the table in question serves its present purpose. Individual test should be made in planning waste heat installations.

TABLE I

Fuel	Lbs. gas from furnace per ton of steel	Total Btu. to boiler per ton of steel	Boiler hp. generated per ton of steel
Natural gas	11,400	1,969,000	55.8
Coke-oven gas	9,650	1,700,000	48.3
Producer gas	14.700	2 476.000	70.0
Oil	10.600	1,809,000	51.3
Tar	11,100	1,853,000	52.5

Boiler Heating Surface Required

The amount of heating surface required in a boiler can be calculated from the formula:

$$\text{Heating surface} = \frac{Q \times H \times f}{T_m \times k} \qquad (2)$$

$$= \text{(approximately)}\ \frac{W\ (T_1 - T_2)\ s}{T_m \times k}$$

where T_m = the mean temperature difference between the gases and the steam, k = the coefficient of heat transfer, Btu. per hr. per sq. ft. per deg. F., Q = lbs. of steam generated per hr., H = heat of vaporization of water (971. Btu.), f = the factor of evaporation for the installation conditions, and W, T_1, T_2, and s have the same value as in formula (1).

Mean temperature difference is determined by the standard logarithmic formula. The coefficient of heat transfer has been given by the formula, derived from the work of various experiments, as:

$$k = a\, b^{\frac{W}{A}} \tag{3}$$

where W = the weight of gases per hour, A = sq. ft. average cross sectional area of the path of gas travel, and the constants a and b are given as follows:

FIRE TUBES			WATER TUBES		
a	Dia. tubes	b	a	Dia. tubes	b
3.5	1 in.	.0013	...	.....	......
2.0	2 in.	.0008	...	.....	......
1.5	3 in.	.00065	...	.....	......
1.1	4 in.	.0005	2.0	4 in.	.0014

It will be seen from this that the rate of heat transfer depends on the ratio W/A, called the mass velocity, on the size of the tubes, and on the type of boiler used. Higher velocities and smaller tubes give higher rates of heat flow. Transfer in fire-tube boilers is lower than in water-tube boilers for a given mass velocity and tube diameter, but, allowing an equal draft loss in the two types, the fire tube can be designed for smaller tubes and a higher velocity, thereby raising the rate of transfer. Variations in mean temperature difference will cause the value of the constants a and b to change somewhat.

Velocity of Gases

In any type of waste-heat boiler, the velocity of the gases through the boiler should be considerably higher than in direct fired practice, due to the small amount of radiation taking place in waste heat practice, heat transfer being effected principally by convection, which is dependent largely upon velocity.

It is very essential that the tubes of either type of boiler be kept clean, both on the gas and on the water sides. Scale removal from fire tubes is particularly difficult, and if possible, only thoroughly treated water should be used. In all waste heat practice, a certain amount of dust collects on the tube surface, even though dust traps and pockets are provided. This is removed by a hand lance in the fire-tube boilers. In water tube boilers, mechanical soot blowers are used to good advantage, with occasional use of a hand lance using either steam or a water spray, atomized by means of compressed air. Compressed air alone does not seem to work out satisfactorily.

The high gas velocity required in waste heat boilers, with the accompanying high draft loss, necessitates the use of induced draft fans. Such fans should be liberal in size, with capacity to handle all gas which might come from the furnace under any operating condition. In no case should the waste heat installation be allowed to interfere with the primary furnace, but on the contrary, the fan should result in even better furnace conditions. For this reason the fan drive is preferably variable speed. Either motor or turbine drive can be used. The turbine has good economy, providing the exhaust steam can be used for feed water heating or some such use. On the other hand, turbines of the size usually required necessitate the use of licensed engineers, with a correspondingly higher operating labor cost. The selection of fan drive should be thoroughly considered, and all points carefully weighed.

The high draft loss through the boiler, together with the draft required by the primary furnace gives a considerably greater draft within the boiler than is customary in direct-fired boilers, often reaching over 4 in. of water. This means that every precaution should be exercised to keep the boiler setting tight, preventing infiltration of air and dilution and cooling of the gas. With Leaky settings, this infiltration of air has been found to be 100 per cent of the gas volume, giving large stack losses and correspondingly low efficiency. Some infiltration will take place through an ordinary brick wall, and for this reason, a heavy coating of an asphaltic mixture should be applied to the outside of the setting. This material should be such that it will remain slightly plastic, so as not to crack and spall. This gives a tight setting, and still allows the brickwork to be inspected for cracks, whereas a steel casing hides any cracks that might occur. The fire tube boiler, with its steel shell taking the place of most of the brickwork, gives less trouble in this respect.

The heat loss due to radiation can be materially reduced by the use of insulating material in the boiler setting. Various kinds of this material are on the market, and it is claimed that by their proper use, radiation can be reduced to less than 1 per cent. The saving thus effected must be balanced against the cost of the insulating material.

Table II gives results of various types of waste heat boilers. The fire-tube boilers show the smallest amount of heating surface per ton of furnace capacity and per bhp., indicating a higher rate of heat transfer. In total heat absorption and output, there appears little to favor either type over the other.

Test of Boiler

Below are the results of a complete check made on a new water-tube boiler, with vertical tubes, three pass, longitudinally baffled:

Tonnage of furnace	75
Kind of fuel	Coke gas and tar
Square feet of heat surface	5220
Square feet of superheating surface	150
Average draft loss through boiler and superheater	2.08 in.

TABLE II

	Fire-Tube Boilers					Water-Tube Boilers Type A.			Type B	
Gas temperature before boiler	1.050	1,231	1,188	1,348	1,338	1,167	1,242	1,082	1,125	1,150
Gas temperature after boiler	492	465	490	485	490	529	555	514	470	485
Boiler hp. developed	363	307	285	258	261	258	308	218	392	472
Gallons oil per hour	375	231	205	152	155	210	coal	260	Coke gas & tar	
Pounds gas per hour	....	53.500	54.500	38.500	39.800	54.920	69,600	49.200	82.110	97,530
Heat surface, sq. ft.	5,000	3,055	3,055	2,350	2 350	4,112	5,073	5,073	5,220	6,960
Draft loss, inches of water	....	1.82	1.87	2.57	2.55	.....	.....	.....	2.08	2.9
Square feet surface per ton furnace capacity	55	60	60	67	67	82	84	84	70	70
Square feet per boiler hp.	About 12					About 18			About 14	

Average gas temperature into boiler and superheater	1125
Average gas temperature out of boiler and superheater	470
Average steam pressure, lbs. gauge	155
Average steam temperature	455
Average actual evaporation, lbs. per hour	12100
Average gross boiler hp.	392
Average net boiler hp., (deducting steam to fan)	359
Average weight of gas, lbs. per hour	82110
Per cent of total heat in fuel in waste gases	52.2
Per cent of total heat in fuel converted into steam	31.0
Per cent of heat in flue gas converted into steam	59.5
Per cent of heat in flue gas in stack loss from boiler	37.6
Per cent of heat in flue gas radiated	2.9
Mean temperature difference between gas and water	442
Average mass velocity of gas	2750
Rate of heat transfer, Btu./hr./sq. ft./deg. F.	5.67
Pounds of waste gas per ton of steel	11300
Pounds of equivalent evaporation per ton of steel	1895
Boiler hp. per ton of steel (gross)	54
Net coal equivalent per ton of steel, lbs.	198
Square feet heating surface per boiler hp.	13.3
Square feet heating surface per ton furnace capacity	69.7
Pounds waste gas per hour per sq. ft. heating surface	15.7

Fig. 1 shows graphically the fluctuations of steam output, rate of fuel feeding, and CO_2 content of the waste gases through the different periods of one complete heat. A maximum peak of 16,000 lbs. of steam per hour (500 boiler hp.) was reached.

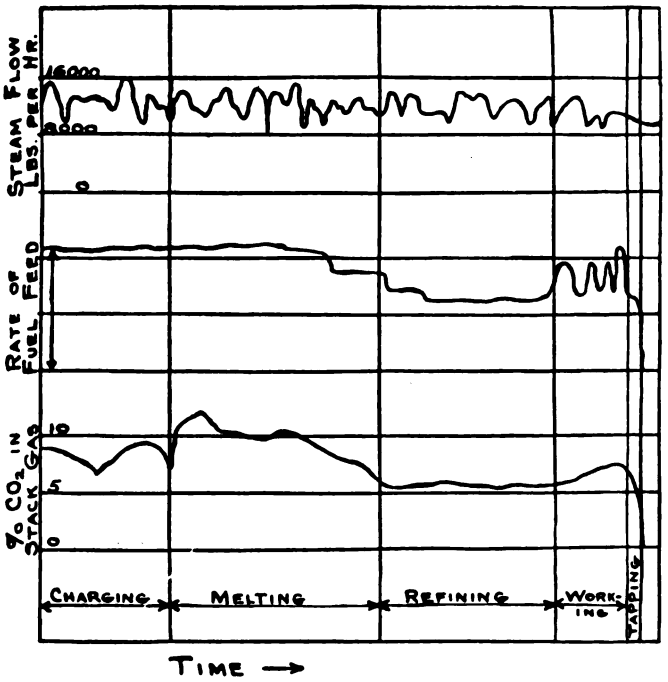


FIG. 1

Every plant presents a different problem and should be subjected to an individual investigation. Costs of installations will vary according to the size of units, available space, etc. Since the coal equivalent is usually charged at a uniform rate depending on the amount of steam produced, variations in operating costs will depend largely on the labor required. This varies with the location and accessibility of the units and the stringency of the boiler laws. Due to the lower temperatures and the absence of fuel or ash handling machinery, stokers, etc., maintenance costs will be lower than with direct-fired boilers. Possible savings shown by an installation depend on the cost of coal in the plant and the various items mentioned above, each of which should be carefully considered in planning an installation. It is, however, safe to say that in practically all cases a decided monetary saving can be shown, not to speak of the step in conservation of natural resources.

The Whiting Corporation Fellowship on Cast Iron at Mellon Institute

Dr. Edward R. Weidlein, director, Mellon Institute of Industrial Research, Pittsburgh, Pa., has announced that the Whiting Corporation, Harvey, Ill., has established an industrial fellowship at the Institute, for the purpose of carrying on investigations on cast iron. Dr. Edward E. Marbaker has been appointed to the incumbency of this fellowship and is now engaged in working out a research program.

As the pioneer builders of foundry equipment the Whiting Corporation has been closely associated with the gray iron foundry and its problems for the past 40 years and is consequently deeply interested in the welfare of foundry technology. The corporation has, in fact, carried on for some years extensive study and systematic development for the purpose of improving equipment and methods for the production of cast iron. While the results of these activities have been beneficial, it has recently been considered advisable to carry on this work on a very much larger scale and on a more strictly scientific basis than would be possible within the limits of a single manufacturing organization. In consequence, the corporation has arranged for an industrial fellowship on cast iron at Mellon Institute, and the results of the followship holder, Dr. Edward E. Marbaker, will be published for the general benefit of the foundry industry.

Dr. Marbaker, the Whiting Corporation Fellow, was graduated from the Towne Scientific School of the University of Pennsylvania in 1910 with the degree of bachelor of science in chemistry, and in 1914 received the degree of doctor of philosophy from the graduate school of the University of Pennsylvania, his thesis being "The Separation of Tungsten from Molybdenum." First employed by the Westinghouse Lamp Company, he carried on considerable original investigation of the platinum metals. He was also a member of the group which designed and built the first plant for the purification of argon. Shortly after receiving his doctorate, he became chief chemist and had charge of the metallurgical laboratory. Considerable time was spent in argon research with extensive use of microchemical analysis. After leaving the Westinghouse Lamp Company in 1917, Dr. Marbaker became connected with Alexander Brothers, manufacturers of leather belting, as chief chemist and later chief engineer, making extensive studies and tests and formulating specifications acceptable to both manufacturers and consumers. From 1920 to 1921 Dr. Marbaker was chief chemist for the Cleveland wire division of the National Lamp Works of the General Electric Company, sepecializing on problems incident to the manufacture of non-sag tungsten wire and molybdenum metals.

Since 1921, Dr. Marbaker has been a fellow of Mellon Institute of Industrial Research conducting various chemical and metallurgical research work. He has from time to time contributed articles to technical periodicals. He is a member of Sigma Xi and Phi Lambda Upsilon, American Chemical Society, American Ceramic Society, American Institute of Chemical Engineers, Franklin Institute, and the American Foundrymen's Association.

The Installation of Centrifugal Pumps

A Practical Discussion Pointing Out the Correct Procedure in Installing and Operating Centrifugal Pumps to Secure Efficient and Satisfactory Service

By JOHN H. JONES*

MUCH has been written of late on the efficiencies developed by present-day centrifugal pumps. The difference in efficiency between the pumps made by the various manufacturers is small, comparatively speaking, and yet the customer requiring such machines will send to the pump manufacturers inquiries as to price and efficiencies developed by their respective pumps; and oftentimes a difference of .5 per cent in efficiency is the deciding factor in the final choice of the pump.

After due consideration has been given to the selection, the pump is purchased and put into operation with such lack of consideration as to pipe arrangements, etc., that as much as 5 or 10 per cent has been lost in its efficiency. So if a little more were written on the manner of installing the pumps, a saving to the users would undoubtedly result. The following may be of interest to such users:

Starting with the pump itself, should it arrive dissembled, place the impellers and the guide wheel in the casing so that the vanes of the impeller turn backwards, while those of the guide wheels should be directed forward.

The pump and motor should set fairly on the baseplate so as not to be strained by the tightening of the bolts; also great care should be taken to see that the pump and motor are correctly centered and in line with each other, or, if belt driven, that the pump shaft is parallel to the countershaft.

Should the suction piping be larger in diameter than the connection on the pump, a conical pipe should be inserted, with a straight top line (in the case of a horizontal main), otherwise an air lock might develop in the higher portion of the pipe.

Should the pump level be above that of the water to be pumped, a foot valve fitted with a strainer must be placed at the end of the suction pipe; but if the water flows into the pump, a gate valve must be inserted in the suction main. A double strainer having two compartments, one of which can be cleaned while the other is in use, can also be inserted to great advantage in keeping dirt and grit out of the pump.

A pressure gauge should be fitted on the suction side of the pump. If this gauge registers a vacuum, it probably means that the strainer needs cleaning out. A pressure gauge should also be fitted at the delivery side of the pump, as close to the pump as possible, for in the case of multiple stage pumps, the pressure reading on this gauge should attain the required pressure before the delivery valve is opened.

In many cases we notice short 90 deg. bends attached to the delivery on the pump casing, as this gives a friction equivalent to about 50 ft. of straight pipe. Either a straight length of pipe or, where not possible, a long sweeping bend should come next to the pump; in fact, wherever bends are necessary they should be made as long as possible. A check valve should be placed between the stop valve and the pump discharge, also a by-pass should be fitted to both these valves so that the pressure may be turned into the main gradually, thus allowing the pressure to build up in the main before opening the gate valve. The by-pass on the gate valve can be used for flooding the pump from the delivery main when starting should the pump be placed above the level of the water, this not being necessary if the pump is below the level of the water, as the water will then run into the pump.

Care should be taken to see that all air is driven out of the pump when it is being filled; for this purpose a small cock is placed on the highest point of the pump. Care should be taken to determine that the delivery pipes are large enough not to cause undue friction.

No air vessels nor relief valves are required on these pumps, as there can be no dangerous increase of pressure in the pump even if the delivery valve is entirely closed; also all regulation of the quantity of discharge should be made by the discharge valve and not by the motor.

The pump should not be allowed to pump against a closed system for any length of time. A small outlet should be arranged for, otherwise the pump will churn and become warm.

With this class of pumps, pressure accumulators are not required.

The pump should never run dry under any circumstances; and, when starting up, the discharge gate valve should not be opened until the pump is up to speed and registering the required pressure; the discharge by-pass valve should be opened slowly and then slowly open the discharge valve. The operator during this operation should particularly watch the ammeter so that he may see that he is not overloading the motor.

When stopping the pump, first close the discharge gate and by-pass valves, then shut off the motor. During frost the pump should be thoroughly drained and air cocks left open.

With a sound air-tight suction main and an observance of the foregoing remarks, there is no reason why centrifugal pumping plants should not give entire satisfaction.

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*Engineering department, Colorado Fuel & Iron Company.

Summer Session at Carnegie Institute of Technology

Courses in engineering subjects, are receiving special attention in the plans for the eleventh summer session this year at the Carnegie Institute of Technology in Pittsburgh. Courses of six and eight weeks will be given, beginning June 11. The college of engineering, according to the announcement, will give summer courses in chemistry, physics, mechanics, surveying, and coal mining. In the college of industries, courses are scheduled in plumbing, welding, sheet metal work, machine practice, woodworking and cabinetmaking, electric wiring and printing.

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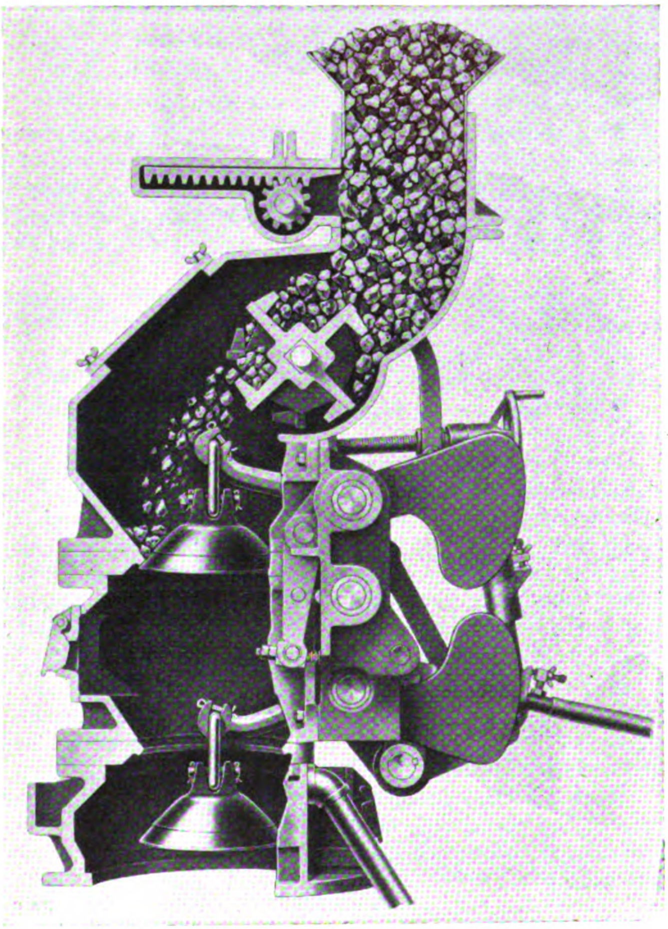
WITH THE EQUIPMENT MANUFACTURERS

New Fuel Feed for Gas Producers

Mechanical coal feeds for gas producers, heretofore available, have been of the revolving, pocketed, vane-wheel type. The Wellman Double-Bell Fuel Feed made by the Wellman-Seaver-Morgan Company, Cleveland, Ohio, operates on an entirely different principle. Two bells are used, which lower and rise alternately, in passing the fuel into the producer. Their operation is mechanically automatic, requiring but a fraction of a horsepower which is supplied by the producer motor, their action being so timed that one bell is open only when the other is closed. The bells and seats are of special alloy steel, machined to secure a closure of a spherical surface against the circular seat. This compels gas tightness even when the parts are worn from long use. The rate of feeding is regulated by the upper rotating, fingered vane-wheel, through the control traveling nut, screw and hand wheel. At the top of the feed there is a shut-off valve section, which, when closed, stops the flow of fuel from the overhead bin, during removal and replacement of the parts below. Any granular fuel may be used, such as bituminous or anthracite coal, coke or lignite, in any size from slack up to 3 in. lumps. The use of this feed insures an even distribution of the fuel in a sprinkled layer on the fuel bed—the volatiles are quickly gasified—and an incandescent bed of coke maintained for the reception of a fresh charge of fuel.



This feed is made in two sizes—one having a capacity up to 5,000 lbs. of coal per hour—and the other having a capacity up to 10,000 lbs. of coal per hour. One feed being sufficient for a producer. The feed is standard equipment on the W-S-M Type L Producer. It is also interchangeable with the previous types of mechanical feeds supplied with Hughes producers and greatly improves their practice.

A New Type Ladle Crane

A 200-ton, seven-motor, four-girder, type Ladle Crane. Forty tons, small or auxiliary trolley. Span 59 ft., designed and built for the Otis Steel Company, Cleveland, Ohio by The Morgan Engineering Company, Alliance, Ohio, it was installed in February, 1928.

The bridge span is 59 ft., and the bridge is composed of four girders. The two outside or main girders support the large or main trolley, while the two inside or auxiliary girders support the small or auxiliary trolley. The design permits full travel of each trolley on its own set of griders, the small trolley passing underneath the large trolley and being entirely independent. The entire bridge is carried on what is termed double compensating trucks; there being a total of eight cast-steel trucks connected by structural steel equalizers with a total of 16 heat-treated steel track wheels 30 in. tread diameter. The bridge has a double drive, being driven by two 85-hp. Crocker Wheeler mill-type motors and full magnetic control is used throughout.

The main trolley is of 200-tons capacity and is supported on four cast steel compensating trucks having a total of eight heat treated steel track wheels 24 in tread diameter. The main trolley frames are composed of heavy structural steel beams with cast steel brackets securely attached. These brackets carry and support the hoist and trolley travel mechanism.

The main hoisting mechanism consists of two interlocked drums driven by two 110 hp. Crocker Wheeler mill-type motors through two trains of worm and spur gearing. Each motor is connected to the driving worm by means of a flexible coupling which compensates for any slight misalignment. The worm is an alloy steel forging, carbonized, heat treated and ground all over and is carried in roller bearings in the cast steel worm housing. The worm wheel is a special bronze alloy rim with hobbed teeth and bolted to a cast steel center, the entire unit being entirely enclosed in a cast steel housing and running in an oil bath.

Under normal conditions each hoisting motor would take an equal share of the load, but should one motor get current and the other fail to get current, the entire load may be temporarily handled by the active motor. This emergency is taken care of by means of the Morgan Patented Compensating Ratchet device, which allows one motor temporarily to lift the entire load without driving the idle motor from the active motor through the slow speed drum gears. The compensating ratchet device is ab solutely necessary where interlocking drums are used, to positively prevent breakage in the hoisting mechanism.

The main hoisting mechanism is provided with 44 parts of 1⅛ in. cable divided into two sets of 22 parts each. Each set of cables consists of two parts which are wrapped on the ends of the two drums with the cables dead ended on an equalizing beam held in the ladle beam.

The auxiliary trolley, which is of 40-tons capacity, has an 85-hp. Crocker Wheeler mill type motor on the hoist, and the trolley is carried on four 18 in. diameter heat-treated track wheels. The trolley frame is a unit steel casting with the motor supports and sheave supports cast integral, thus eliminating loose and bolted-on parts.

All sheaves throughout are equipped with Hyatt roller bearings and the bridge trucks are so arranged that Hyatt roller bearings may be added if desired.

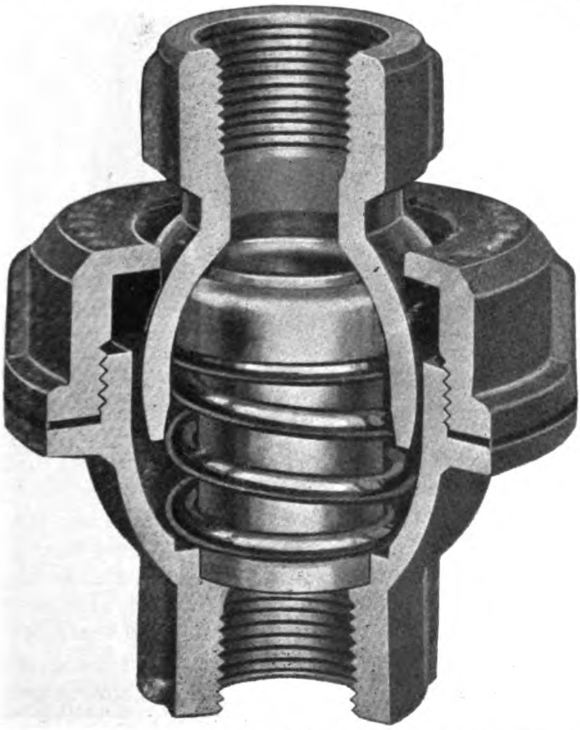
Flexible Pipe Joint

The Flexible Pipe Joint shown requires no adjustment of any kind at any time to keep it leakproof.

Originally conceived and developed to automatically compensate for expansion and contraction on water chilled, steam vulcanizing molds, it is particularly suitable for use on water cooled open hearth doors, etc.

In addition to allowing for the vertical rise and fall, it is not affected by any accidental outward movement of the doors that may take place during loading operations.

Reference to the cut will show a ball member, in contact with a bone-hard heat resistant gasket. A non-corrosive spring actuates a follower on the tubular guide, maintaining the ball in contact with the seal gasket at all times. This feature, in addition to eliminating leakage, also prevents grit or dirt from lodging between ball and gasket, thus preventing scoring of ball or gasket. A simple but ingenious method of locking the follower on the guide tube, limits the spring travel and makes it a three piece joint—no parts can fall out if opened. Installation is made under any condition without opening or disturbing the joint—both on straight or angle types.



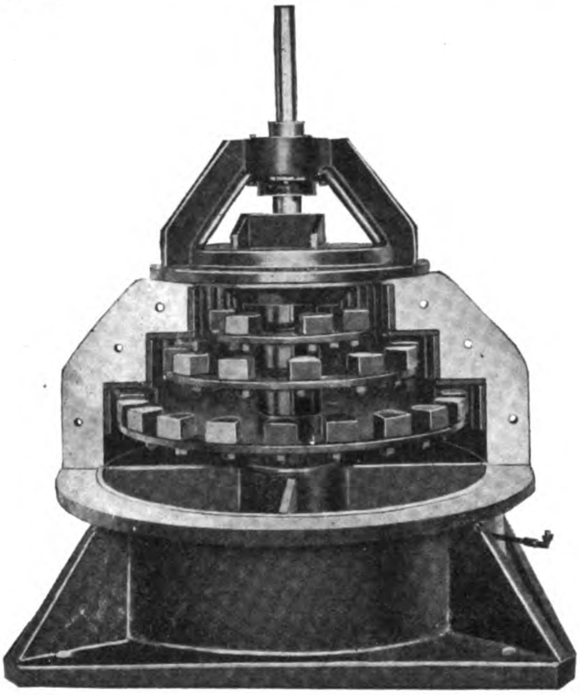
There are many other uses for a joint of this description in steel plants, as its action is universal, so is its uses. The one type of joint it is claimed will handle steam, air, water, gas, oil, gasoline, etc.

Pipe breakage or loosening is eliminated, as under no conditions can the ball freeze, bind or stick in the joint—yet piping is never loose or wobbly, owing to the positive action of the spring in each individual joint.

These joints are patented and manufactured by the Lonsdale Brass Works, Inc., Pittsburgh, Pa.

The Centripact Pulverizer

The Centripact Pulverizer is extremely simple in design and construction. The object in view has been the minimizing of wear, decreasing of power and the pulverizing of materials to a fineness heretofore not attained.



The pulverizing action combines both impact and attrition, and thereby eliminates the rubbing and grinding methods used in many other types. Naturally in their elimination, there is a great deal of wear eliminated, and a big reduction in power consumed.

It will be noted from the illustration that there are three horizontal discs. The top disc has the smallest diameter, while the bottom disc is of largest diameter. Upon each disc are mounted chilled manganese steel hammers which are bolted firmly into a recessed slot in each disc. There is no chance of these hammers becoming loose. Opposite each row of hammers is a circular breaker ring which presents a corrugated face toward the hammer.

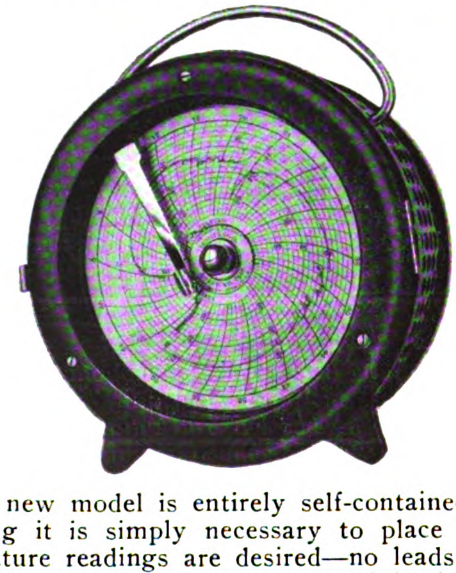
As the material is fed into the top of the pulverizer, it naturally has to pass to the center of the first disc. Centrifugal force throws it into the line of hammers. As the hammers revolve the material is driven against the breaker rings. The rebound of each piece of material will be in proportion to its actual size. As it impacts upon the breaker ring, there is a shattering effect from which a goodly percentage of fines are a natural result. These fines are swept down to the center of the second disc. The large pieces which rebound in the first disc are again hit by successive hammer blows until they have been broken into finer material, which passes to the second row. In the same way, material will be driven to the second breaker ring, shattered and passed down to the third row. From the third disc, it passes to the discharge, which is in the form of a spout beneath.

The Centripact pulverizer, without air separation, has pulverized damp bituminous coal 90 per cent through 300 mesh, has pulverized the hardest flint rock from 1½ in. down to 85 per cent through 200 mesh, has pulverized mica, damp clay, cast iron chips, shellacs, all kinds of iron ores, oxides, pigments, etc. In other words, the claim which is made for it—"Pulverizes anything" has been very well substantiated in the ease with which the Centripact operates upon many materials, which in an average mill, have been found most difficult. The manufacturers claim for this machine an exceedingly large tonnage at a very low cost for power and replacement.

Centripact is distributed in the entire east by George F. Pettinos, 1206 Locust Street, Philadelphia, and is manufactured by the Centripact Pulverizer Corporation of Denver.

Develops New Small Size Atmospheric Recording Thermometer

Of unusual interest to users of recording thermometers will be the latest addition to the "Bristol's" line: a miniature size instrument using a chart, but 4 in. in diameter, developed by The Bristol Company, Waterbury, Conn. Charts used are designed with particular attention to the type of service required, and offer very clear readings over appropriate ranges.

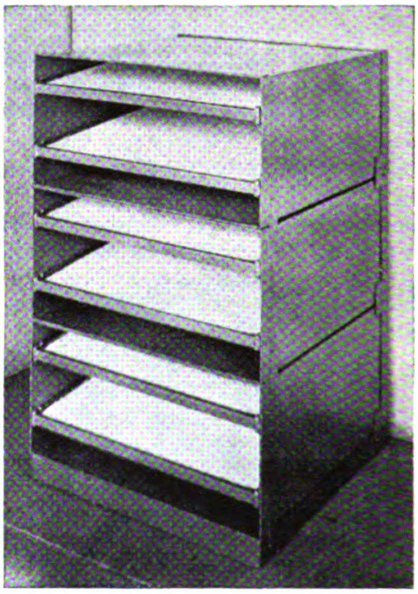


The new model is entirely self-contained. When installing it is simply necessary to place wherever temperature readings are desired—no leads or other form of connections are needed. Light in weight; equipped with convenient handle and leg rests, thus easily portable. The case is also designed to permit of mounting on wall, post or other support if desired.

Every care has been taken to insure accurate, dependable readings and trouble-free operation. The measuring element consists of a bi-metallic helix which is positive in operation and extremely sensitive to temperature changes. The penarm is attached to the measuring element and records directly on the chart without the aid of any intervening or complicated multiplying devices. A special frictionless form of inverted penarm with fountain pen is standard equipment, assuring a sufficient supply of ink, and a uniform record line over the complete chart revolution of 72 hours. The clock used to revolve the chart is specially made for the purpose, having all parts plated with a rust-proof preparation to safe-guard against any possible action of moisture.

New Unit Air Filter Uses Cellulose Filter Medium

The National Air Filter Company, Chicago, has announced the commercialization of a new unit type air filter for cleaning air used in cooling large motors, compressed air, and similar purposes. A blanket of cellulose material is the dirt collecting medium, an entirely new idea in this field. The new material, developed by the Kimberly-Clark Company especially for the new filter, consists of a mat of many layers of very fine cellulose fibers. It will be known commercially as "Airmat."



In an exhaustive series of experimental tests the new filter medium has shown a high efficiency in stripping the air passed through it, not only of the most minute particles of solid matter, but of all particles of oil and oily soot so common in smokey city air. Added to its high cleaning efficiency, this filter has been able to show less operating costs.

A single unit consists of a sheet metal box 12 in. high, 24 in. wide, and 24 in. long with a filtering capacity of 1,000 cu. ft. of air per minute. These units can be used singly or placed in multiple installations.

In addition to the 1,000 cu. ft. unit type a second type of continuous filter has also been developed for applying "Airmat" where automatically-renewed, "constant effect" filters are needed. In this type the filter blanket is fed onto a drum from a continuous roll. As the exposed part of the blanket gradually becomes choked with dirt, the loss of head in the air flow automatically actuates the drum and fresh filter blanket is fed into place as the dirty portion is removed.

TRADE PUBLICATIONS

Statistical bulletin No. 1, for 1928, has been mailed from the offices of the American Iron and Steel Institute, 75 West Street, New York City. This bulletin lists the 1927 output of ferro-alloys, pig iron of all grades, methods of casting pig iron, production of pig iron by states, etc.

* * *

"Elesco-operation" is the title of a booklet distributed by The Superheater Company, of 17 East 42nd Street, New York City. It briefly touches upon the organization of the company and its activities in the power plant field. Copies can be obtained from the above address.

* * *

Sangamo meters are described in Bulletin No. 67 received from the Sangamo Electric Company, Springfield, Ill. The construction of the meter is detailed together with its operating characteristics.

* * *

In Bulletin GEA-916, the General Electric Company gives a brief description of the function of The Cottrell Precipitation Process, and of the electrical equipment necessary to make it operative. Considerable space is devoted to certain pieces of equipment such as transformers, Kenotron rectifiers, switchboards, etc.

* * *

U. S. Bureau of Standards under the program of elimination of waste by simplified practice issues a bulletin on the packing of carriage machine and lag bolts, 18 pages, price 5 cents.

* * *

The American Society of Mechanical Engineers 29 W. 39th Street, New York City, announces the new engineering weekly card index service making available the facilities of the United Engineering Societies Library which covers more than 1,700 technical publications from 37 countries, 17 languages. Class A service for large institutions includes all index cards on all subjects and the bound volumes of the Engineering index. Class B service covers any of the main classifications, while Class C covers subclassifications as selected.

* * *

Bulletin 1143 Allis-Chalmers Manufacturing Company, Milwaukee, Wis., describes the normal torque type-ARX line start induction motors with a table of ratings.

* * *

Bulletins have been received from the General Electric Company, Schenectady, N. Y., as follows: GEA-137A—Synchronous motors types TS and QS "6000 series" small sizes slow speed for direct connection to reciprocating compressors, exciters and control. GEA-467A CR 7022—Automatic starters for slip ring motors. GEA-808A—Totally enclosed fan cooled induction motors, "500 series." GEA-914 CR 9441, LS 424A—Limit switch for use on control circuits only, a.c. or d.c., 600 volts maximum.

* * *

A booklet outlining a plan for a national conference for the discussion of the question of proper sales and distribution of products of American manufacturers which are distributed either all or in part through the hardware, jobbing and mill supply channels, is being distributed by the Bolt, Nut and Rivet Industry, Charles J. Graham, president of the Bolt, Nut and Rivet Manufacturers Association, 311 Ross Street, Pittsburgh.

* * *

A four-page folder from Hyatt Roller Bearing Company features the use of roller bearings on ingot buggies and steel mill cars pointing out the saving of locomotive power and reduction in repair costs.

* * *

Reliance Electric & Engineering Company, Ivanhoe Road, Cleveland, Ohio, manufacturers of a.c. and d.c. motors has issued bulletin No. 202 for January covering "Type T," heavy duty d.c. "Reliance" motors with ball and roller bearings and including a dimensional table.

* * *

The Use of Silica Gel as a Medium for Drying Blast," is the title of a pamphlet being distributed by The Silica Gel Corporation, Garrett Building, Baltimore, Md. It is the reprint of a paper delivered by Edwin H. Lewis, M.A., of the Glasgow Iron & Steel Company Ltd., before the Iron and Steel Institute at the September meeting in Glasgow, Scotland. The pamphlet is profusely illustrated and the text very adequately describes the process of removing moisture by passing the air through Silica Gel.

* * *

"Metal Statistics," twenty-first annual edition, for 1928, published by the American Metal Market, of Cliff Street, New York City, can now be obtained at the usual price of $2.00. The book contains authoritative information such as prices, tonnages, etc., on both ferrous and non-ferrous metals over a period of some years. The size is 4¼ x 6⅛ in. and the number of pages is 552.

* * *

Ingersoll-Rand Company, of 11 Broadway, New York, has just completed the sixth edition of a 140-page, two color book entitled, "100 and 1 Ways to Save Money with Portable Compressors." In this book are embodied comparative cost data on portable air compressors and air-operated tools (rock drills, paving breakers, clay diggers, backfill tampers, grinders, hoists, riveting hammers, chippers, metal drills, etc.). The information has been put together in handy-reference, cross-index form. In most cases, figures are presented on a man-hour basis so that they can be readily applied to local conditions anywhere. Free copies may be obtained by writing to Ingersoll-Rand Company, or any of its local branches.

* * *

"Compensated Draft" has been made the title of Buletin No. 104 distributed by the Hagan Corporation. This bulletin explains the principles involved in the system of boiler furnace control devised and patented by this corporation. Much of the text relates to a particular method of controlling the air to and gases from, the fire bed, but the bulletin as a whole furnishes considerable information on the correct manner of firing boilers. Bulletin No. 101 describes the Hagan Master Regulator by means of which the mechanical movement of parts in making effective compensated draft, is secured. Copies may be secured by addressing the corporation at 304 Ross Street, Pittsburgh, Pa.

TRADE NOTES

The materials handling division of the American Society of Mechanical Engineers held a meeting of national scope in Philadelphia on April 23 and 24, the objective being to help industry overcome the enormous waste that exists in material handling work.

Among the papers presented was one by Arthur F. Case, manager of the coal and ore handling division of The Wellman-Seaver-Morgan Company, Cleveland, Ohio, entitled "Bulk Material Handling at Docks and Storage Plants."

* * *

The General Electric Company will occupy booths Nos. 375, 377, 379 and 381 at the convenion of the American Foundrymen's Association in Philadelphia, Pa., May 14 to 18, 1928. The exhibit will consist of welding equipment, motors and control and a foundry cupola blowing equipment. T. H. Reeves will be the General Electric representative in charge of the exhibit.

* * *

The Central Public Service Corporation has arranged to meet its increased gas requirements at Rockford, Ill., with Becker Type Ovens. A contract has been awarded to the Koppers Construction Company for the construction of the plant.

The installation will consist of 21 Becker Type combination ovens with a daily gas capacity of approximately 3,500,000 cu. ft. Auxiliaries include two Koppers gas producers, a by-product plant with equipment for the production of ammonium sulphate and a coal and coke handling plant.

* * *

The Timken Roller Bearing Company of Canton, Ohio, have placed a contract with The Rust Engineering Company for two continuous bloom reheating furnaces for their new bar mill. These furnaces will each heat 40 gross tons of alloy blooms per hour, blooms being 10 in. by 10 in. and 18 ft. in length.

The blooms will be charged in the end of the furnace and pushed throughout its length of 69 ft., being discharged by gravity to the roll table. The Rust furnaces were chosen by The Timken Roller Bearing Company after careful consideration of all present types of furnaces doing similar work and should be of great interest to the steel trade due to the unusual method of firing which is employed. The furnaces are of Rust triple-fired type (patent applied for), utilizing a soaking chamber at the discharge end which is separate from the main portion of the heating furnace and is independently controlled as to temperature. This feature permits the condition of the steel being discharged to be uniform at all times and completely independent of the rate of firing and the tonnage output.

The Rust refractory tile recuperator will be utilized on these furnaces to deliver highly preheated air to the main furnace firing ports. The fuel to be used will be natural gas.

* * *

The Newton Steel Company have recently placed an order with The Rust Engineering Company for the construction of two additional 155 ft. long Kathner type roller bottom sheet normalizing furnaces. These two furnaces will be the same in practically all regards as the two furnaces just recently completed, with the exception that one will be 84 in. wide instead of 72 in., which is the width of the other three. The Kathner type shafts and discs will be supplied by The Duraloy Company. In the Kathner design of shaft, the entire alloy hub and disc is protected from any cooling effect, since the water-cooled shaft upon which it is mounted is completely insulated.

Shortly after the first two furnaces were put in operation, it was seen that this design of shaft was very efficient and the extremely low fuel and labor costs caused the Newton Steel Company to immediately place an order for two additional furnaces.

* * *

Orders received by the General Electric Company for the first three months of the present year amounted to $79,925,840, compared with $77,550,581 for the corresponding quarter in 1927, an increase of 3 per cent, and with $86,433,658 for the first quarter of 1926.

* * *

Arrangements to purchase the Hemco plant, trademarks, patents and processes by the Bryant Electric Company of Bridgeport, Conn., is a transaction, which will interest the electrical industry. The Bryant Electric Company has been making wiring devices for 40 years.

The Bryant line consists of metal shell and porcelain lamp receptacles and sockets and their accessories; and surface and flush switches; fuse and fuse holders; baseboard receptacles and plugs; rosettes; cord connectors; hospital equipment, etc.

The Hemco Electric Manufacturing Company has been in business as makers of molded sockets, molded plates and other composition parts for electrical purposes for many years.

* * *

The American Steel & Wire Company recently placed an order with the Surface Combustion Company for a 22-ton capacity continuous billet reheating furnace, for their Cuyahoga works. The furnace dimensions will be approximately 13½ ft. wide by 45 ft. long, end discharge type, and will be equipped with automatic proportioning gas firing equipment and recuperator.

* * *

As of April 1, 1928, the R. D. Nuttall Company's commercial activities will be handled by and through the parent company, the Westinghouse Electric & Mfg. Company. All inquiries, etc., should be addressed to the nearest Westinghouse district office. Mr. J. E. Mullen, formerly assistant sales manager of the R. D. Nuttall Company will head up the new commercial setup with offices at the Nuttall plant, McCandless Avenue at Butler Street, Pittsburgh, Pa.

* * *

The Trico Fuse Manufacturing Company, Milwaukee, Wis., makers of Trico fuses, announce the removal of their Pittsburgh office to new and larger quarters at 405 Penn Avenue.

Mr. Wm. A. Bittner, and his staff are in charge and ready to give immediate attention to users and prospective customers.

* * *

Due to the large increase in business in Detroit and vicinity, The Brown Instrument Company has secured larger quarters for its Detroit branch at 576 Maccabee Building, Detroit, Mich. Mr. R. W. Mayer is the district manager.

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NEWS OF THE PLANTS

The Colonial Iron Company, blew out its blast furnace at Riddlesburg, Pa., prior to April 15. The furnace will be relined and is expected to be put back in blast about the middle of June.

* * *

The Carnegie Steel Company will rebuild and enlarge No. 2 stack at the Ohio Works, Youngstown, Ohio. When completed the furnace will have a capacity of 800 tons daily being the largest of the group of six furnaces. The Pennsylvania Engineering Works, New Castle, Pa., will do the work.

* * *

The Pittsburgh Steel Company is planning extensive improvements including the general electrification of the Monessen plant involving a new boiler plant to operate with steam at 400 lbs. pressure with 200 deg. superheat and partial electrification of the mill drives, and changes in the automatic mills at the Allenport, Pa., works to increase the lengths of hot finished tubes from 25 ft. maximum to 40 ft. maximum. Additional heating furnace capacity will also be installed at the Allenport works.

* * *

Two combined coke pushers, coal levelers and door extractors will be installed at the South Chicago plant of the Youngstown Sheet & Tube Company. The contract was awarded to the Wellman-Seaver-Morgan Company by the Koppers Company, general contractor for the coke-oven plant.

* * *

The Woodward Iron Company, of Woodward, Ala., has awarded to the Semet-Solvay Engineering Corporation of New York, a contract for the construction of a complete new Semet-Solvay coke-handling system, including wharf, screening and loading plant. The new equipment is planned to take care of the entire output of 230 ovens, estimated up to 2,500 tons of coke daily.

The run of oven coke will be discharged on an inclined coke wharf of the latest improved type, 160 ft. long. The coke will be delivered to a 42-in. belt conveyor and carried to the screens. Grizzly screens of proper size for the production of furnace and foundry coke will separate the smaller sizes. A conveyor will deposit the coke in cars.

* * *

The Carnegie Steel Company recently made a record in its river department in transporting 51,000 net tons of coal in one day on the Monogahela River. This material was delivered to Clairton by 10 steamboats in 60 barges within a 24-hour period. The Clairton by-product plant, the largest of its kind in the world, which receives all of its coal by river, at present is using 40 barges of 850 tons capacity of coal daily. The average daily loading at the mines is 59 barges, with a total of more than 50,000 tons.

* * *

It is reported that the Timken Roller Bearing Company, in connection with its steel mill expansion program, is planning a large addition to its seamless tube department, because of increased volume of business, both in bearings and steel.

The American Steel & Wire Company has put into operation a new welded fabric mill addition at its plant at Anderson, Ind.

* * *

At the recent annual meeting of the Pacific Coast Steel Company, D. E. McLaughlin a former vice president, was elected president to succeed E. M. Wilson, deceased. William Pigott, Sr., a director, was named to new post of chairman of the board, and Henry M. Robinson, president of Los Angeles First National Bank, was elected a director. Other directors were re-elected.

* * *

The Carnegie Steel Company, is reported to have authorized construction of a 10-in. hoop mill at Youngstown, Ohio, to cost approximately $1,000,000. The work to be completed within a year.

* * *

The erection of an additional building by the Quaker City Iron Works, at Aramingo and Ontario Streets, Philadelphia, will increase the production capacity 50 per cent, according to an announcement by J. A. Jensen, secretary of the company.

* * *

The Barde Steel Company will erect three heavily-timbered steel warehouses at its Seattle plant, 2709 Utah Street. The buildings will each be two stories, 37 x 120, 32 x 120 and 67 x 120 ft.

COMING MEETINGS

May 8-9—American Refractories Institute. Annual meeting, White Sulphur Springs, W. Va. Dorothy A. Texter, 2202 Oliver Building, Pittsburgh, secretary.

* * *

May 14-17—American Society of Mechanical Engineers. Spring meeting, William Penn Hotel, Pittsburgh. Calvin W. Rice, 29 West Thirty-ninth Street, New York, secretary.

* * *

May 14-18—American Foundrymen's Association. Annual meeting and exhibition, Commercial Museum, Philadelphia. C. E. Hoyt, 140 S. Dearborn Street, Chicago, secretary.

* * *

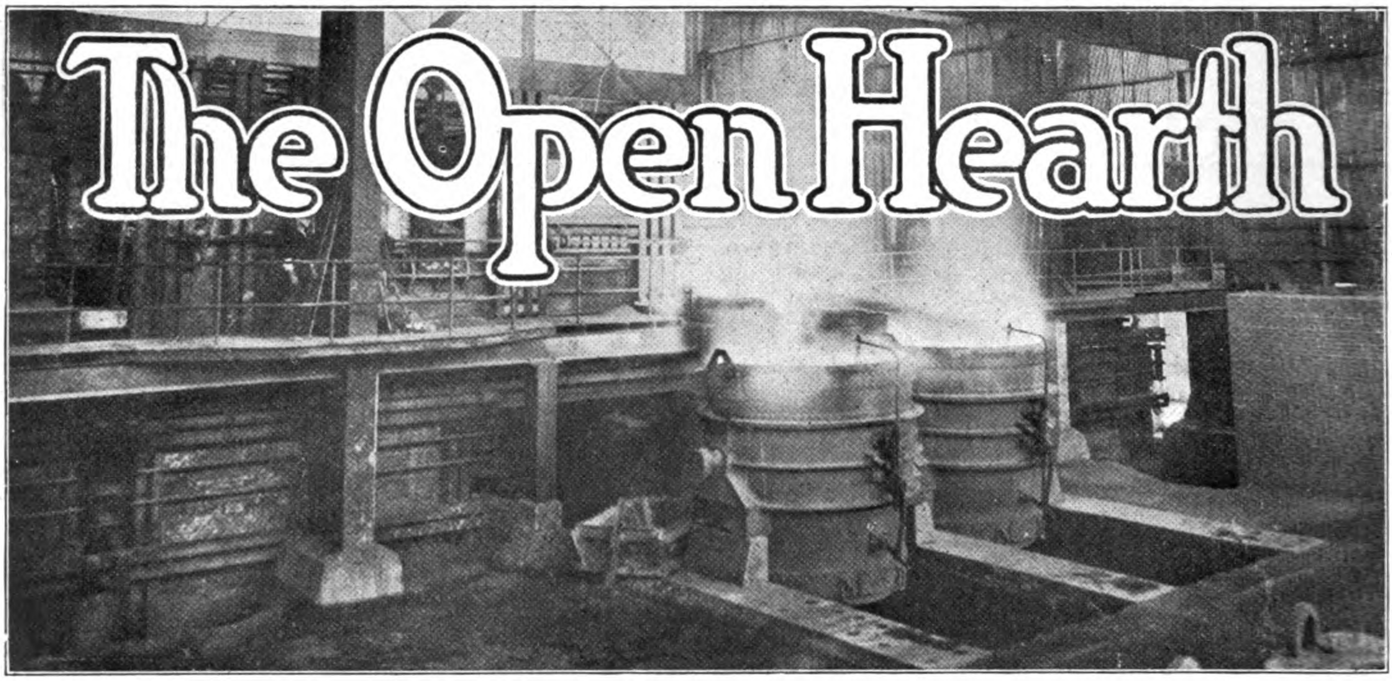
May 25—American Iron and Steel Institute. Annual meeting, Hotel Commodore, New York. E. A. S. Clarke, 75 West Street, New York, secretary.

* * *

June 14-16—American Society of Mechanical Engineers, National Oil and Gas Power meeting, Pennsylvania State College, State College, Pa. Calvin C. Rice, secretary, 29 W. Thirty-ninth Street, New York City.

* * *

June 25-29—American Society for Testing Materials. Annual meeting at the Chalfonte-Hadden Hall, Atlantic City, N. J. C. L. Warwick, secretary, 1315 Spruce Street, Philadelphia, Pa.



I. Lamont Hughes, vice president of Carnegie Steel Company and E. P. Thomas, president of the United States Steel Products Company, have been appointed additional vice presidents of the United States Steel Corporation. Acting under James A. Farrell, president. Mr. Hughes will be in charge of the manufacturing operations and Mr. Thomas will direct the sales of iron and steel products.

* * *

John S. Oursler, general superintendent of the Homestead Steel Works has been appointed vice president of the Carnegie Steel Company to succeed I. Lamont Hughes.

* * *

R. H. Watson, assistant general superintendent of the Homestead Steel Works has been made general superintendent succeeding John R. Oursler.

* * *

C. B. S. Jackson, who for six years has been superintendent of the Norton Iron Works, Ashland, Ky., has been made superintendent of the Texas Nail & Wire Manufacturing Company, Galveston, Texas.

* * *

D. E. McLaughlin, formerly vice president of the Pacific Coast Steel Company, San Francisco, Cal., has been made president of the company. William Pigott was named as chairman of the board.

* * *

Thomas J. Bray, for the past 17 years president of the Republic Iron & Steel Company, has resigned in order to be relieved of active duties. Mr. Bray was born in Pittsburgh in 1867 and served his apprenticeship with the Lewis Foundry & Machine Company, and graduated later as mechanical engineer from Lehigh University. He has been identified with the Ohio Steel Company, the New Castle Sheet & Tin Plate Company, and the United Engineering & Foundry Company, of which he was chief engineer. He resigned this latter connection to go to the Republic Iron & Steel Company in 1907, being successively assistant to the president, vice president and president.

Philip Stremmel, who has been acting superintendent of the Granite City Steel Company, Granite City, Ill., has been made general superintendent.

* * *

E. H. Gartrell was made president and manager of the Ashland Fire Brick Company, Ashland, Ky., at a recent meeting of the directors of the company.

* * *

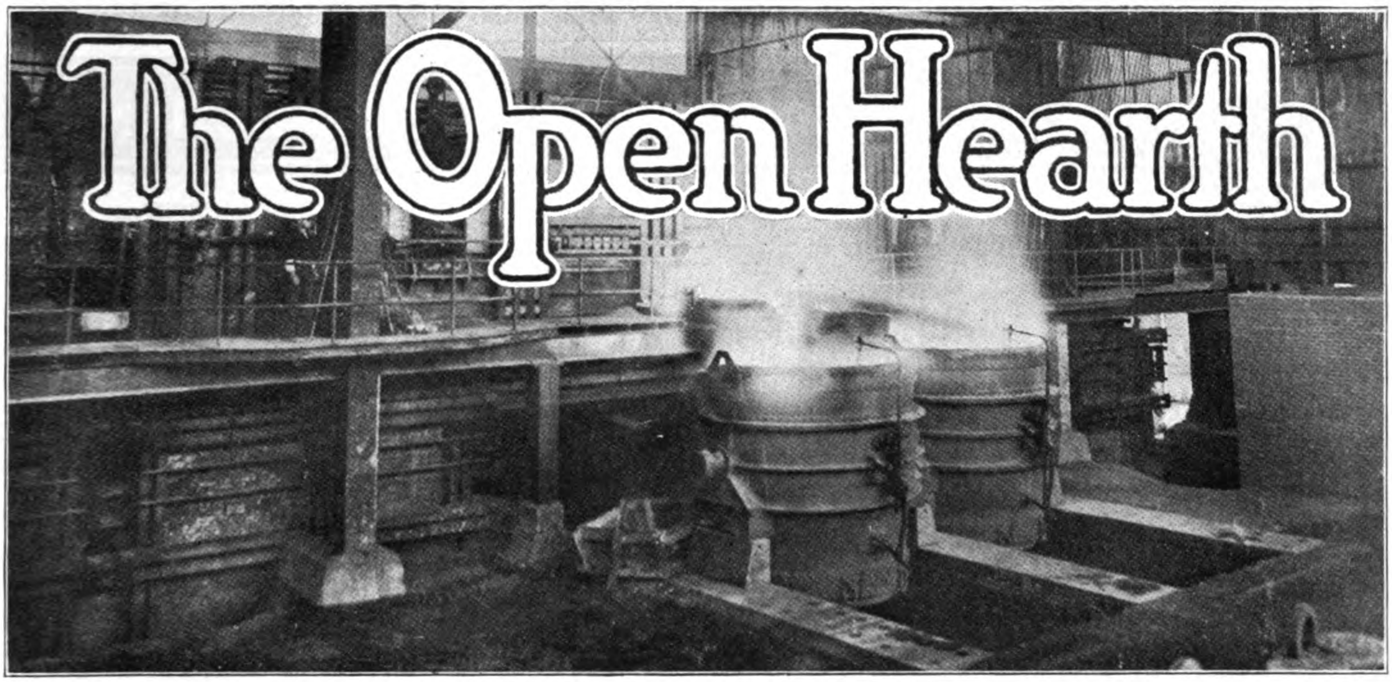
O. W. Young, formerly located with the western division sales office of the Hyatt Roller Bearing Company, has been appointed chief engineer and takes up his new duties at the company headquarters in Newark, N. J., Mr. Young joined the forces of the Hyatt Roller Bearing Company in 1915 as sales engineer, serving in that capacity for several years, then taking charge of all engineering activities of the western division, and during the last two years as assistant manager of that division in charge of sales covering the tractor and agricultural equipment industry. He is an active member of the S. A. E. and other engineering societies, having served as vice president of tractor engineering of the Society of Automotive Engineers, also chairman of the Chicago section during 1926-1927.

* * *

J. H. Edmonds has been appointed general manager of the Lebanon plant of the Bethlehem Steel Company, to fill the vacancy caused by the death of Mr. John Penn Brock. Mr. J. A. Kinney becomes assistant general manager.

* * *

Charles M. Easterly, vice president of the Inland Steel Company of Wisconsin, has resigned. He is president of the Capital City Culvert Company, Madison, Wis., and will move his offices from Milwaukee, to that city. Mr. Easterly has been district sales manager for the Inland company for about 18 years, and before his association with that company, was representative of the Berger Manufacturing Company, and the Stark Rolling Mill Company, now the Central Alloy Steel Company, both of Canton, Ohio.



The Open Hearth

Charles H. Claypool, general superintendent for the Tod-Stambaugh Company on the Mesabi iron range with headquarters at Hibbing, Minn., has become assistant general manager of the Woodward Iron Company, Woodward, Ala. The Woodward Iron Company is producer of merchant pig iron, operating its own iron ore and coal mines.

* * *

Wilfred H. Cunningham, president and chairman of the board of the Lake Superior Corporation, steel and transport interest, has resigned both offices. Robert Dodd, of Montreal, Que., has been appointed to succeed Mr. Cunningham. Mr. Cunningham retains the offices of vice president and director.

* * *

Jack Singleton, general manager and chief engineer of the Capital Iron Works, Topeka, Kans., for the past seven years, has resigned to become a technical director of the American Institute of Steel Construction, New York.

* * *

Carl F. Scott, manager of building equipment sales, General Electric Company, has entered the employ of the Gurney Elevator Company in New York, as assistant sales manager. Mr. Scott is a graduate of Haverford College, and has been in the employ of the General Electric Company since 1908. At the time of leaving that company he had charge of the sale of electric equipment for elevators.

* * *

Jos. H. Jeffcott, has recently become associated with the Vulcan Mold & Iron Company, in the sales and Service department taking the place of Thomas Windsor Evans, resigned. Mr. Jeffcott has been connected with the iron and steel industry for the past 20 years in both operating and sales capacities. His early experience was in the ingot mold foundry of the Bethlehem Steel Company where he later was in charge of the Lower Works open-hearth department. He has also been connected with Donner Steel Company, as open-hearth superintendent and more recently with Jones & Laughlin Steel Corporation at the Soho plant.

O. W. Irwin has been appointed manager of the steel joist department of the Truscon Steel Company, Youngstown, Ohio. He succeeds John Bowditch, Jr., who has resigned to locate in Pittsburgh. Mr. Irwin has been in the Truscon sales department for many years.

* * *

Frederick A. Westphal has been appointed superintendent of the wire department now under construction at the plant of the Sheffield Steel Corporation, Kansas City, Mo., Mr. Westphal is a graduate of the United States Naval Academy, Annapolis, Md. He started with the American Steel & Wire Company, as a foreman and wire rope engineer at the Worcester, Mass., plant and the New York office, where, with the exception of two years overseas with the First Division, A. E. F., he continued until 1922. At that time he resigned to become assistant superintendent of the rod and wire department at the Aliquippa works of the Jones & Laughlin Steel Corp., Pittsburgh, where he remained until taking over his present situation.

Gray Iron Foundrymen Plan Institute

At a recent meeting of representative producers of gray iron castings held in the College of Industries Building, Carnegie Institute of Technology, Pittsburgh, Pa., a resolution was adopted providing for the establishment of a permanent organization. The purpose of the organization will be to improve the quality and extend the uses of gray iron castings and to study the marketing and producing problems of the industry. A nominating committee was selected consisting of Walter A. Wood, R. D. Wood & Company, Philadelphia, chairman; D. K. Bartlett, Builders Iron Foundry, Providence, R. I.; R. M. Ensign, Ensign Foundry Company, Toledo, Ohio; Wm. Bornfleth, Cream City Foundry, Milwaukee, and B. H. Johnson, Cresson-Morris Company, Philadelphia. The organization committee will consist of 15 members and two alternates.

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THE STEEL PLANT ROLL TURNER AND DESIGNER

An Authority on Roll Design

T. A. Hall

T. A. Hall, roll designer of the American Rolling Mill Company, who has bourne a full share of the responsibility in the development of the practice of the American Rolling Mill Company at Middletown and Ashland in their new methods of sheet mill rolling.

Mr. Hall has spent a lifetime in this line of work and is an authority on sheet mill practice.

Co-operation of Engineer, Roll Designer, and Roll Maker

In the new developments which are taking place in the rolling of metals, three men have equally important parts. The engineer conceives a new idea for producing greater tonnage. He creates entirely new types of mills and rearranges existing types. With each new creation or rearrangement, new sizes of rolls or newly designed systems of roll passes are required. Taking up the idea of the engineer, the roll designer re-designs his roll passes to meet the new conditions. He reduces the number of passes required to produce the same sections or he rearranges the successive past designs to produce new shapes. The roll designer having completed his work, the roll maker is called upon to produce a roll which will meet the new demands. It will probably be called upon to withstand greater strains caused by heavier reductions or impart, a better finish required on the new shape. It is therefore obvious that in order to produce best results in the finished product these three men, the engineer, roll designer, and roll maker, must co-operate to the fullest extent The engineer and designer who are generally in a position to observe the working of the new mill can secure first hand information which will guide them in correcting faults or making further changes for better or greater production. The roll maker does not have this opportunity and he is therefore dependent upon the information given him by the other two to guide him in correcting defects in his rolls. Knowing the exact conditions which the roll must meet in service, the roll maker proceeds to change the composition of his rolls or methods of casting so that they will give the deired results in the mill.

An Example of Roll Design for a Three-High Blooming Mill*

Given: Ingot 21 x 23 in., bloom 9 x 10 in., number of passes 9, size of mill 42 in.

Required: To design rolls for the mill.

Solution—First: The draught on each pass is found. In finding the draughts it is to be borne in mind that the draughts on the bottom passes, being edging passes, should be heavier than on the top passes; that it is well to take the heaviest draughts on the first bottom passes while the steel is hot and the piece is short, which will prevent great strains on the engine as the momentum of the fly wheel will carry across a short length; that the top passes are best made of equal draughts; and that little work can be done on the finishing pass. The reductions in size of the ingot to the bloom calls for 12 in. on one side and 13 in. on the other, or a total of 25 in. Since the reductions on the bottom passes are to be greater than those on the top, let this total draught be apportioned to give 10 in. on top passes and 15 in. on bottom ones. The draught on each top pass will then be 2½ in. The draught on the bottom passes may be arbitrarily apportioned, but to accord with the cautions stated above, they are determined by trial, and to give the total reduction of 15 in. they should, apparently, be apportioned as follows: No. 1 pass, 3½ in.; No. 3 pass, 3¾ in.; No. 5 pass, 3½ in.; No. 7 pass, 3¼ in.; No. 9 pass, 1 in. The complete plan for working the ingot down to size would then be as follows:

Size of the original ingot, 21 x 23 in.

No. 1 pass, bot., draught 3½"; size of bloom prod., 21 " x 19½".
No. 2 pass, top, draught 2½"; size of bloom prod., 21 " x 17 ".
Piece edged.
No. 3 pass, bot., draught 3¾"; size of bloom prod., 17¼" x 17 ".
No. 4 pass, top, draught 2½"; size of bloom prod., 14¾" x 17 ".
Piece edged.
No. 5 pass, bot., draught 3½"; size of bloom prod., 14¾" x 13½".
No. 6 pass, top, draught 2½"; size of bloom prod., 14¾" x 11 ".
Piece edged.
No. 7 pass, bot., draught 3¼"; size of bloom prod., 11½" x 11 ".
No. 8 pass, top, draught 2½"; size of bloom prod., 9 " x 11 ".
Piece edged.
No. 9 pass, bot., draught 1 "; size of bloom prod., 9 " x 10 ".

(To be continued)

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*The Making, Shaping and Treating of Steel. Carnegie Steel Company.

THE STEEL PLANT BRICK MASON

W. G. Owen with General Refractories

Mr. W. G. Owen, formerly sales manager of the Haws Refractories Company, Johnstown, Pa., has joined the sales force of the General Refractories Company, Philadelphia. Mr. Owen will assume charge of the Philadelphia territory, relieving Mr. L. Tschirky, who will devote his time to general sales promotion and the sales development of the company's specialty products.

Harbison-Walker Elects Directors

At the annual meeting of stockholders of the Harbison-Walker Refractories Company, James Dilworth of the Dilworth Porter Company, representing interests of the Missisippi Glass Company and the Walsh Fireclay Company; A. B. Clements, representing interests of the American Arch Company; S. C. Brookes, Jr., representing interests of the Continental Share Company of Cleveland; and Richard K. Mellon were elected directors. The regular quarterly dividends of 1½ per cent on the common and on the preferred were declared.

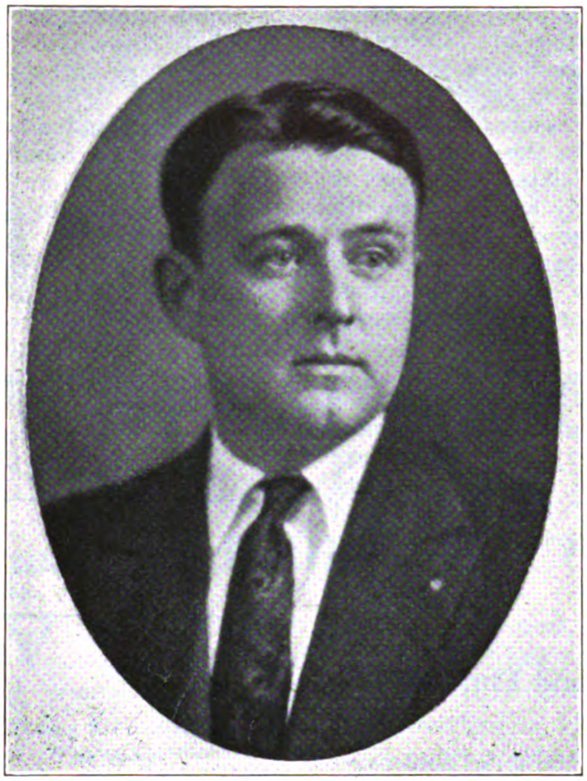
Henry Maurer & Son Elects New Officers

At the annual meeting of Henry Maurer & Son, manufacturers of refractory clay products, Henry D. Faber was elected a vice president. Mr. Faber has been with Maurer for many years, devoting himself mainly to sales development. He is well known in the boiler furnace industry, in central power stations and individual plants and gas works.

Stuart M. Frame was elected secretary, and George Haffner was appointed general plant manager.

H. D. Savage Made President of Combustion Engineering Corporation

H. D. Savage, for some years an official of the Ashland Fire Brick Company, and the first president of the Refractory Manufacturers Association, has been chosen president of the Combustion Engineering Corporation. He advances from the position of vice president of the corporation. In 1914 Mr. Savage was vice president of the American Arch Company.



J. G. Hanes, superintendent of brickmasons at the Trumbull Steel Company, Warren, Ohio.

Annual Meeting of American Refractories Institute

This year the annual meeting of the American Refractories Institute will be held at The Greenbrier, White Sulphur Springs, Tuesday, May 8. The important feature of the meeting will be the discussion of a select list of specifications used by consumers at the present time for the purchase of refractories. An effort is being made to have a well balanced attendance between the consuming and producing interest. With such a representation of those interested it is planned to discuss in detail the various phases of specifications in a non-technical way so as to indicate their merits and faults.

A practical specification is one which compromises between the requirements for an ideal refractory and one which can be manufactured at a reasonable profit. It is believed that the discussion which will take place will be of considerable value to consumers in formulating more practical requirements; and the manufacturers will benefit by obtaining viewpoints of the consumers and through learning more of the requirements of refractories in various furnace operations.

A cordial invitation to attend this meeting is extended to everyone interested in such specifications. The Refractories Institute will welcome suggestions and any specifications you may wish to offer for open discussion. For further particulars address the Secretary, 2202 Oliver Building, Pittsburgh, Pa.

The remainder of the day will be taken up by business transactions, committee reports and several papers. The two papers given below will be presented.

"Screening of Fire Clays."

"The Cause of Bulging in Hand-Made Shapes." This paper has been prepared by the Refractories Fellowship at Mellon Institute, and is a continuation of an open forum on the subject at the December meeting.

Brick from Slag

Ash and clinker utilization. A serious problem arising in modern super-power stations is the disposal of the ash and clinker. Obviously 1000 tons of coal every 24 hours, which is a not uncommon consumption, means for most installations 150 tons of ash during this time, corresponding to about fifteen 10-ton railway trucks. Of considerable interest, therefore, is the calcium-silicate or sand-lime brick process, whereby ash and clinker, as well as sand, spent shale, and blast furnace slag, can be converted into high-grade bricks. This scientific process, which is now progressing in Great Britain, consists, in its primary form, of mixing sand with 5-10 per cent of its weight in good-quality lime, which has been thoroughly slaked, so that no trace of quicklime is left, together with a small amount of water. Afterwards the plastic mass is passed through a continuous brick press or molding machine, and subsequently the shapes are stacked on a series of small wagons and heated in a long iron cylinder or autoclave for, say, four to eight hours by blowing in steam at 120-180 lb. pressure; this results in a chemical combination between the lime and the sand to form hydrated calcium silciates. The mass is bound together, giving an extremely hard and smooth brick resembling natural stone, the exact duration of the heating depending on the steam pressure used. For ash and clinker, however, as well as the other material, which, unlike sand, is not pure silica, steam at atmospheric pressure only is sufficient, the lime combining with the free silica present or the unsaturated silicates. The bricks possess all the advantages of the ordinary burnt-clay product in the way of strength, durability, and porosity, while they are pleasing in appearance, with the valuable property also that each brick is a "facing" brick, being dead straight at the edges, without any bulging, warping, or distortion.

—World Power.

Missouri Diaspore, Burley, and Flint Clays*

By C. R. Forbes†

In the state of Missouri, about 100 miles southwest of the city of St. Louis, are found what, so far, constitute the most important deposits of diaspore clay in the United States. Associated with the diaspore clay are burley and flint fire clays. For many years the flint clay was mined in this district and the burley and diaspore clays were discarded as waste and were referred to as "sandy clays." About 10 years ago the high alumina content of these "sandy clays" was discovered and since then there has been an increasing demand for them in the manufacture of high alumina or "super" refractories.

Production

The production of the district for the year 1926, according to figures of the Missouri Bureau of Geology and Mines, and the U. S. Bureau of Mines, was 18,400 tons of diaspore clay and 93,500 tons of flint clay. As these figures do not include production by companies using the material in their own plants, it is probable that the actual tonnage produced was much greater. The production comes from a number of small operations, very few pits producing more than 40 or 50 tons per day.

Character and Uses of Clays

The chemical composition and softening points of four typical clays from this district are given in Table I.

It will be noted from a study of these analyses that the chief difference in these clays is in their alumina and silica content. The clays intermediate in alumina content between flint fire clay and diaspore clay are known in the district as burley clays. The name was given by the miners to those clays containing oolites of the mineral diaspore (Al_2O_3-H_2O), which were known to them as "burls." Several grades of this clay are found varying from the rough or "burley" flint clay to an open textured material approaching diapore clay in appearance and chemical composition. There is no well established line between the different grades of clay, but an arbitrary classification sometimes used is as follows: diaspore clay material containing 70 per cent or more alumina; first grade burley clay material containing from 60 per cent to 70 per cent alumina; second grade burley clay material containing from 50 per cent to 60 per cent alumina.

TABLE I
Analyses of Typical Clays from District

	Flint fire clay	Second grade burley clay	First grade burley clay	Diaspore clay
Silica	43.58	30.38	16.37	6.56
Alumina	38.45	52.25	63.82	72.72
Ferric oxide	1.36	2.01	1.84	2.37
Lime	0.14	0.08	0.22	0.00
Magnesia	0.39	0.08	0.08	0.00
Titania	2.45	2.10	3.15	3.65
Soda	0.55	0.30	0.43	0.57
Potash	0.13	0.14	0.57	0.43
Ignition loss	13.54	13.11	13.91	13.88
Total	100.59	100.45	100.39	100.18
Softening point	Cone 34	Cone 36 to 37	Cone 37 to 38	Cone 40

Uses

The diaspore clay, which derives its name from the mineral diaspore, is an extremely valuable and useful material for the manufacture of high alumina or "super" refractories. These refractories have been found to be exceptionally well suited to certain severe uses, such as linings for cement and lime kilns, glass tank blocks, boiler settings, and the like, and their perfection by ceramic engineers has been a distinct contribution to American industry. A small tonnage of diaspore clay is used annually for the manufacture of abrasives. For this purpose it should contain less than 7 per cent silica, but a high percentage of iron is not objectionable, and some high iron, abrasive grade, "red diaspore" is being mined in the district.

The burley clays from this district are being used more and more for the manufacture of different grades

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*Abstract of paper presented at the annual meeting, American Ceramic Society, Atlantic City, N. J., February, 1928.

†Professor of mining, Missouri School of Mines and Metallurgy.

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of high alumina refractories and the flint fire clay is used chiefly in the manufacture of high grade fire brick.

Future of the District

Because of the nature of the deposits it is very difficult to make any estimate regarding the reserve tonnage of the differnt clays. The total tonnage of high grade diaspore has been variously estimated at from 750,000 to 1,500,000 tons. There is a considerable tonnage of high iron burley and diaspore clay that, as yet, is not commercially available. A practical method of separating the iron from the clay would add materially to the ore reserves. Burley clay is much more plentiful than diaspore, and there is undoubtedly a large reserve tonnage of this material. Flint fire clay is abundant, but on account of the low price can only be mined, at present, from deposits close to the railroad.

—Journal American Ceramic Society.

Heat Penetration in Refractories*

By M. C. Booze†

Furnace operators and refractories manufacturers usually hold that porous hand-made fire brick are much better heat insulators than denser brick made by other manufacturing methods. While it is certainly true that voids or pores lower the heat conductivity, the effect is dependent upon pore size, continuity, number of pores and other factors, so that general statements are apt to be misleading. Laboratory determinations on fireclay brick have shown that the differences in commercial fireclay brick due to differences in porosity are almost negligible, although in the case of checker brick there is an advantage in using dense material because of the greater heat capacity.

In industrial furnaces, heat is carried to the refractory walls by radiation and by conduction from the gases or air present in the furnace. With other factors constant, the amount of heat radiated from furnace gases varies as the fourth power of temperature, so that radiation in modern high temperature industrial furnaces is by far the more important factor in transferring heat to the furnace walls. At the face of the wall there is a surface or skin effect which offers some resistance to the inward flow of heat; the amount of resistance being determined by the physical condition of the surface (such as smoothness) and by the nature of the surface material itself. After passing the surface the heat penetrates further into the wall, raising the temperature of the refractory material, and when the latter becomes saturated, passes on and is absorbed either by cooling air or other material in contact with the outer wall face. When the oustide of the wall is bare and exposed to the air there will be a decided temperature drop or gradient, ranging from the furnace temperature on the hot face to only 100 deg. or so on the outside. When insulated, however, the gradient is much less because the heat cannot escape so readily. This gradient approximates a straight line and the heat effect upon the refractory material in producing vitrification is only noticeable a short distance from the hot face. However, when joints are open or cracks exist the heat enters by direct radiation or gas circulation and so raises the temperature abnormally in the wall to the depth of the openings. It is because of the temperature drop through the walls that fireclay brick are able to support heavy loads even though the furnace temperature is high.

Where radiation is the important factor in transfering heat to furnace walls, as it is in most furnaces, cooling by means of air or water boxes reduces the outer face temperature without appreciably affecting the temperature of the hot face.

Brick for Heating Furnaces

The type of brick to be used in heating furnaces varies with the conditions of operation. Where the temperatures are extremely high, refractoriness is all-important and a relatively short life can be expected. In others where the temperatures are high, but not excessive, good grades of highly silicious clay brick have been found to be very satisfactory. Refractoriness, constancy in volume, and rigidity while hot are the important factors.

Preliminary Report of the Manganese Situation, 1927

Domestic shipments of manganese ore containing 35 per cent and more of metallic manganese totaled in 1927 approximately 43,600 long tons, valued at $1,142,000, according to preliminary figures compiled by the United States Bureau of Mines, Department of Commerce. This is a decrease of six per cent from the 1926 shipments, which amounted to 46,258 tons. The decrease in average value per ton of all ore shipped in 1927 is due in part to the decreased world's price of metallurgical ore and also to the decreased shipments of chemical ore in comparison with those of metallurgical ore. The shipments of metallurgical ore amounted to 26,000 tons, valued at $416,000, while those of 1926 were 26,530 tons, valued at $379,893. The shipments of chemical ore in 1927 amounted to 17,600 tons, valued at $726,000, while those of 1926, were 19,728 tons, valued at $848,770.

In 1926 the Butte, Mont., district shipped 1263 tons of rhodocrosite ore and in 1927, 6800 tons having a manganese content of 37 per cent. The major part of the 1927 shipment was calcined at Trident, Mont., and yielded 3600 tons of 55.9 per cent material which was shipped east. The combined shipments from Butte of calcined ore plus crude ore, chiefly for metallurgical use, amounted to 4014 tons. In the early part of August shipments of ferruginous manganese ore from Leadville, Colo., were resumed. The shipments of manganese ore from Arizona, Arkansas, Idaho, Montana and New Mexico showed increases over 1926.

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*American Refractories Institute Bulletin.

†Member, Research Advisory Committee, American Refractories Institute. Vice president, The Chas. Taylor Sons Company.

SAFETY FIRST IN THE STEEL PLANT

No Fatal Accident in Two Years

A period of two years has elapsed at the Southside works of the Jones & Laughlin Steel Corporation without a fatal accident. The last fatality at this plant occurred April 3, 1926, and since that date there has not been a man killed at this large plant with its numerous hazardous activities.

Steel Man President

J. M. Woltz of the Youngstown Sheet & Tube Company, Youngstown, Ohio, has been elected president of the Society of Ohio Safety Engineers.

Safety Engineering Conference

Under the auspices of the Western Pennsylvania Safety Council, Pittsburgh's fifth annual safety engineering conference was held on April 19. Papers were delivered by P. G. Fenlon of the Duquesne Works of the Carnegie Steel Company, J. A. Oartel of the Carnegie Steel Company, John T. Ryan of the Mine Safety Appliance Company, Earl F. Blank of the Jones & Laughlin Steel Company, and Dr. R. R. Jones of the Bell Telephone Company. The address at the evening session was by E. W. Corn of the National Safety Council, Chicago. "Maintaining Safe Physical Conditions in and About the Plant," was the subject of a symposium at the afternoon session.

T. H. McKenney is supervisor of safety at a plant—the Illinois Steel Company—that was one of the pioneers of the safety movement. Mr. McKenney is also supervisor of labor at the South Works and a member of the executive committee of the National Safety Council.

Prepare Program for Safety Congress

Program preparations are now being made for the Seventeenth Annual Safety Congress which will be held at New York from October 1-5, inclusive when fully five hotels will be required to accommodate the thousands of delegates, the hundreds of speakers and scores of sessions, according to an announcement made by W. H. Cameron, managing director of the National Safety Council.

According to present indications, the facilities of the Hotels Commodore, Martinique, McAlpin, Pennsylvania and Waldorf-Astoria will be utilized for the various events. A New York Congress Correlating Committee has bee nappointed to prepare preliminary plans for local Congress activities.

Coke Oven Accidents

Recently released Bureau of Mines statistics show that accidents at coke ovens in the United States in 1926 caused 51 deaths and 1922 lost-time injuries. During this time 23,115 men were employed at all plants with an average of 315 workdays per man.

Due to a large explosion in an Indiana by-product plant accident rates were considerably increased for 1926. If this single explosion is eliminated, the death rate works out at 1.48 per 1000 men employed and the injury rate at 77. Of the 1922 lost-time injuries reported, the great majority, or 1402, were very minor ones.

The chief causes of the fatal accidents were gas explosions, falls of persons, coke cars, railway cars, falling objects and burns; while non-fatal injuries mostly resulted from burns, coke cars, falling objects, falls of persons and hand tools.

It is interesting to note that the larger plants have lower accident rates per man employed than small plants; and that steady employment usually results in a lessened accident rate.

—Gas Age Record.

Another Record

Hubbard & Company, Pittsburgh, Pa., with 110 employees in their tool department engaged in forging, hot press and hammer operations, completed on January 25 a period of 270 calendar days without a lost time accident, actual working days being 162, with a total of 17,820 man days.

Bulletin on Health

"Health and Recreation Activities in Industrial Establishments, 1926," is the subject of Bulletin 458 edited by the U. S. Department of Labor. The bulletin contains 94 pages of very interesting information concerning the promotion of welfare by companies employing large numbers of persons. This publication should have a special appeal to directors of safety first as it is really a treatise on this subject and the out-of-hours activities of employees. Illustrations are quite profuse. Copies may be procured from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price 25 cents per copy.